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Photograph by courtesy of U. S. Forest Service

"Dipping" or collecting the drippings from the filled "cup": minimum damage to tree and no loss of material

"CUPPING" vs. "BOXING" **(See page 36)**

Flotation for the Practical Mill Man*

A Description of Several Important Factors in Concentration by Flotation

By Frederick G. Moses, Salt Lake City, Utah

It is a well known fact that the difficulties encountered in flotation plants in different sections of the country are many and varied. While it is true that, in the great majority of mills, the troubles are soon located and remedied, there are many other plants which are not so fortunate in the solution of their problems. It is usually found in the latter case that, although there is nothing apparently wrong with the mill or its operation, the results being obtained are not so good as the experimental work on the ore had led the builders to believe could be obtained. Because a profit is being made, the idea of leaving well enough alone often leads the operators into the state of mind in which they are satisfied to make the best of a bad situation and to be content with the results that they can get.

There are some cases in which the mill results are not satisfactory and, moreover, cannot be readily improved. This is, however, seldom the case. More often the poor results are caused by some condition, often a simple one, that can easily be remedied, if located. Unfortunately, there is such a multiplicity of conditions, any one of which can cause poor flotation results, that it is hopeless for the average mill operator to investigate more than a comparatively few possibilities.

It will be the object of this discussion to suggest some of the factors affecting flotation results, and to suggest ways in which some of them may be overcome. Of course, it will be possible to consider only a limited number of the conditions that work for poor flotation results. There is always the chance, however, that a discussion of some of the more common difficulties encountered in flotation plants will suggest the manner by which some specific or unusual source of trouble can be discovered and eliminated.

FLOTATION A CONCENTRATION PROCESS.

It is imperative that the fact that flotation is a concentration process, as much as any gravity scheme, be borne in mind. If this fact is remembered when considering any phase of flotation, the solution of the problems connected with its operation will be considerably simplified.

As flotation is a concentration process, it must follow that the economic laws of concentration will apply to it as much as to the gravity concentrator. In every case of concentration there is a maximum extraction and grade of concentrate possible. This theoretical result can be approached in the commercial installation, but never reached. Usually the greatest obstructions in the way of obtaining scientific results are the economical considerations that surround the mill operator on all sides. The plant must be run to make the greatest profits, and attempts to obtain better metallurgical results will often serve only to reduce the profits.

It must also be borne in mind that, like a table, the capacity of a flotation machine is limited. Notwithstanding the fact that the maximum capacity is but seldom reached, there is always the possibility that this be done, to the detriment of the results obtained on the machines. If the operator takes care that the apparatus is not overloaded, he has eliminated many of the chances for poor work in his plant.

The crushing of flotation feed is as important to good flotation results as the crushing of table feed is important to good table work. The sizes that can be floated are limited to a fewer number than can be tabled successfully, and poor sizing or classification of flotation feed can cause even more unsatisfactory results than in gravity machines. The ore must, of necessity, be crushed fine enough to free the maximum quantity of mineral, but with the production of the minimum amount of slime or very fine material. The slimes, especially the true colloidal material, will be found to be more often the cause of poor flotation than any other factor that will be encountered in the plant.

EXTRACTION AND GRADE OF CONCENTRATE.

The metallurgical and economical success of the flotation plant depends on the recovery of the greatest amount of the valuable mineral from the ore in the purest possible concentrate. Just what are the economical limits of extraction and grade of concentrates depends on local conditions and must be determined for each mill; in the present discussion, they will be considered to be the best metallurgical results allowable under the conditions existing in the locality of the mill.

As already suggested, each ore has a maximum and definite ratio of concentration, and hence there is a maximum grade of concentrate possible. The maximum extraction is, of course, 100 per cent. of the values in the ore, a figure that can only be approached. The important fact to be remembered in this connection is that in the flotation plant, as in the gravity mill, recovery can be increased only at the expense of grade of concentrate, and vice versa. The flotation operators who remember this fact will save themselves much trouble and worry that always follow attempts made to obtain scientifically impossible results. Unfortunately, so few plants are approaching theoretical results that their consideration can be eliminated from the present discussion.

FLOTATION RECOVERIES.

Ignoring, for the present, the consideration of grade of concentrate, it can be said that extraction by flotation depends on many factors, among the most important of which are: (1) The physical condition of the ore being treated, (2) the flow sheet of the mill, and (3) the effectiveness of the flotation operation. While the first two are not so important as the last, they are so often the cause of flotation difficulties that they should be considered.

At the present time, the mineral values that occur in the ore as sulphides are all that can be depended upon to be recovered by flotation. When only non-oxidized sulphides are present, it should be possible, theoretically, to obtain high metallic extractions. However, when such easily oxidized material as iron sulphide is present and carries values, as often happens, trouble in obtaining good recoveries may be encountered. There have been put on record cases in which this material, by simply lying in the ore bins for a short time, has undergone enough oxidization to make the flotation of the iron sulphides very difficult. The remedy, of course, for a condition of this sort is to mill the material as soon as possible after it has been hoisted.

The size of the sulphide particles occurring in the ore greatly affects the possible recovery from an ore. When this sulphide reaches the flotation machines in very coarse sizes it will not float. Unfortunately, on the other hand, when the sulphide particles have been ground too fine, or "slimed," they can be floated only with difficulty. In most cases it will be found that the greatest loss in the tailings from a flotation plant is in the minus 200-mesh material. Proper crushing previous to flotation will correct these conditions to a great extent. However, the actual size and condition of the sulphide, as it occurs in the ore, will be a very dominant factor.

All ores carrying decomposed or kaolinized minerals are difficult to float. This physical condition will probably have more effect on the actual flotation operation and its results than any other single thing that could be mentioned, and at the same time it is the most difficult to overcome. Why clay and other colloidal material have such harmful effects is difficult, at best, to explain on a scientific basis. A discussion of this point will delve so deeply into the pure theory of flotation as to be out of place in this consideration. Instead, a few suggestions about means of eliminating or controlling this material will be more to the point.

There may be said to be two general schemes by which the detrimental effect of slime may be overcome. The first and most important is by flocculation or precipitation by chemical or electrochemical schemes. The second and least used method is that of washing. Heating of the ore before crushing is sometimes tried.

Rather than give a long scientific definition of just what colloidal material is, it will be better to give a very simple method of determining the presence and amount of this material. Colloidal material, or more commonly "slime," can be best detected and its quantity estimated by the slowness with which it will settle in water. A rough application of this scheme can be made by taking a portion of the flotation pulp and shaking it thoroughly in a bottle. If there is any quantity of colloids or slime present the water will remain murky after standing for a few minutes. If this cloudy appearance persists for half an hour there is probably sufficient slime present in the pulp to interfere with flotation.

The amount of the slime that may be present may be roughly estimated by the depth of clear water that appears on top of the pulp in a given time. Of course, this means will only give comparative results, but this is all that would be required except in special cases.

REMOVAL OF SLIME.

Some simple chemical compounds, under certain definite but usually little understood conditions, have the property of causing the suspended or deflocculated slime in the pulp to collect together, or flocculate, changing the physical conditions in such a way that rapid settling occurs. It has been found by experiment that slime in this condition usually has very much less harmful effects on flotation than when deflocculated. Sulphuric acid, lime sodium carbonate, acid sodium sulphate, copper sulphate and many other substances, when used in very small amounts, have the property, under certain conditions, of flocculating the slimes. In this way their harmful effects are very largely removed.

At the present stage of our knowledge of this phase of flotation, it is practically impossible to foretell which of the numerous reagents that have been used for this purpose will give the required results on a particular ore. The most effective one can only be determined by experiment under the conditions under which it is to be used. The reason for this is our lack of knowledge of the real manner in which they act on the slimes in the ore.

The ideal manner of ascertaining the reagent to be used is by direct experimentation in the commercial cells of the operating plant. If, for any reason, this is not feasible, indicative results can sometimes be obtained by a series of tests made in bottles. Several samples of the pulp from the flotation machines, containing the oils being used, are placed in a series of bottles and well shaken. Two or three drops from solutions of the various reagents are then added to the bottles, a separate bottle being used for testing any one solution. The bottles are then placed where they will be free from vibration for an hour or more. It will be seen, at the end of this period, that some of the bottles have a certain volume of clear water above the cloudy pulp and that, in certain cases, this volume will vary widely. It is usually the case that the reagent showing the greatest settling effect will produce the best results when used in the cells. However, this is not always the case.

The removal of slimes or colloids by washing is a more difficult matter, requiring quite an installation of settling tanks or thickeners, and a comparatively large supply of fresh, pure water. This last item is of the utmost importance. The actual operation of the scheme is quite simple. The pulp, before being floated, is settled in the thickening tanks, which are so operated as to give the thickest spigot product possible, without allowing the overflow to carry away an excessive amount of valuable mineral. The overflow, which carries a large portion of the slime material, is allowed to run to waste, and the thick spigot product is diluted with sufficient clean, fresh water to give the correct pulp density for flotation. This method has worked well in several large plants in the West.

Another scheme which might be used, but which for various practical and economical drawbacks has received but scant attention, involves heating the ore before crushing to a temperature great enough to put the slime-forming material in the ore into such a physical condition that slime formation is retarded when the ore is wetted and crushed.

There are many materials foreign to the ore, such as decomposed vegetable matter, lubricating oils from line shafts or crusher bearings, soap, sewage, grease from mine-car wheels, etc., that will interfere greatly with flotation. The only sensible remedy for this type of trouble is to eliminate the source of it. Great care must be taken to prevent these substances from getting into the flotation feed. The great difficulty often encountered in finding the source of this sort of interference makes it imperative that care be used to eliminate it.

MILL FLOWSHEETS AND THEIR EFFECTS.

Sometimes it does not seem possible that such a simple matter as the location of a table in a flotation mill could make any great difference in the results obtained. Nevertheless this has often been proved to be the case.

*Reprinted from *Chem. Metall. Engineering.*

It is as necessary that the flowsheet of a plant using flotation be as carefully worked out by experiment as when gravity processes only are to be used. Many flotation plants can be shown to be doing unsatisfactory work for this reason alone.

In many instances, the ore should be tabled previous to flotation in order to remove the heavy sulphides which are present but which cannot be floated. These will only tend to build up in the machines, choking up the cells and preventing their efficient operation. Also, it is sometimes possible so to remove from the pulp certain deleterious substances, such as slimes.

In certain cases the best results demand that the pulp be tabled after flotation. A great tendency in many flotation plants is to carry too dilute pulp in the flotation apparatus. Tabling before flotation is bound to add water to the flotation feed and this causes poor operation. Tabling following flotation has not this drawback.

The use of pilots by which the work of the flotation machines can be judged should not be overlooked in this connection. The flotation operators can soon be taught from the appearance of the tables treating the flotation tailings whether the cells are doing good, bad or indifferent work. They thus have an optical demonstration of what their part of the general scheme is accomplishing, and this will always work toward securing better results from the flotation machines.

Before leaving the discussion of mill flowsheets and their bearing on flotation results, the effects of various types of crushing on flotation results should be mentioned. This is one of the things that is without the pale of help from the operator, but some valuable suggestions may be evidenced by the consideration.

There is no doubt that the type of crushing to which the ore has been subjected before flotation will have a noticeable effect on the results obtained. The well-known case of the Inspiration mill, where a better result was obtained by crushing with iron on iron than by pebbles on iron, is an example of what a difference such a simple point can make.

The fact that the type of crushing which produces a large amount of slime is not as satisfactory as that which will produce the minimum quantity has been already suggested. A certain plant in Arizona is divided into two units, exactly alike, except for different types of crushing machines employed in them. The ore, flotation equipment and other factors are the same. The extractions obtained in the two units always varied to a certain extent, and the difference in the crushing was the only explanation that could be offered as the reason for this peculiar behavior.

Flotation has a definite field in saving that portion of the sulphide content of an ore that is too fine for satisfactory gravity work. It can never be made to replace tables satisfactorily, except under an unusual combination of circumstances. Stage crushing, therefore, with the removal of the mineral as soon as it is freed, followed by flotation of the sulphides that have been crushed too finely for table work, in general seems to be the best and most logical scheme, and should be followed whenever possible.

EFFECTIVENESS OF FLOTATION OPERATION.

The points already discussed have been mentioned because of their indirect effect on flotation. There are, also, certain factors in the operation of the flotation equipment itself that are of even more importance to good flotation results than those already mentioned.

One of the most important factors in good flotation is the oils or combinations of oils that are being used. If all of the other conditions are perfect with the exception of the oil, good flotation results are impossible. Unfortunately, the investigation of oils covers such a large field and depends on so many little understood or unknown factors, that no definite rules for determining the most satisfactory oil can be given.

As long as the art of flotation has been practiced, the only feasible method of determining the oil best adapted for an ore has been by laboratory or mill experiments. This method of investigation involves much time, patience and money, but the importance of the information gained always justifies the expenditure. The operator should never reach the state of mind that permits him to be satisfied with the oil he is employing. He should test all of the logical mixtures available, and as new oils come on the market, they should, also, be given their chance.

The agitation to which the oil and pulp have been subjected is the next important factor in good flotation results. This must be correct, both with regard to kind and amount. The lack of sufficient agitation is usually evident at once, but too much is more difficult to recognize and is just as harmful as the opposite state of affairs.

Too much agitation will do one of two things: either produce too much froth, usually of an unsatisfactory character, or cause the oils to be so thoroughly emulsified as to destroy much of their flotation value. It is very probable that the principal function of much of the acid used in flotation is to throw oils out of emulsion that have received too much agitation in the ore pulp.

If the mechanical agitator type of machine is not designed correctly for the ore which it is to treat, it will either produce too much froth or too little. Either of these conditions will tend to cause poor recovery. When the ratio of the size of the agitator and its speed is correct, or that of the agitator compartment to the froth tank or spitzkasten, the quantity of froth produced by the use of the right amount of oil will be wrong. In such a case, the common method of attempting to rectify conditions is by changing the amount of oil used. This is unsatisfactory in most cases.

If too little froth is being made by the machine by the use of the correct amount of oil, air blown into the pulp at the bottom of the spitzkasten will often correct matters very satisfactorily.

The troubles caused by the production of too much froth when the correct amount of oil is being used are much more difficult to rectify. The greatest chance for improvement, under these conditions, is to increase the tonnage to the machine, although other factors may cause this scheme to fail.

Over-oiling the flotation pulp will usually be indicated by the occurrence of large amounts of mineral-bearing froth in the launders carrying the tailings from the machines, or on the tables or other apparatus that may be used to re-treat the flotation tailings.

IMPORTANCE OF PURE WATER.

One of the greatest necessities for good flotation work is a large and constant supply of fresh and pure water. It is considered good flotation practice to settle the water from the flotation tailings for re-use in the flotation circuit, in order to obtain the benefit of the oils that will be returned to the mill in this manner. This is logical and works very well, within certain limits. A point that must at the same time be considered is that the soluble constituents of the ore or oils will gradually be concentrated in this return water, and will eventually attain an accumulation that will interfere very materially with the operation of the flotation machines. For this reason, increasing the amount of fresh water that is being added to the flotation circuit will often work wonders in the way of improving flotation results. This fact is very easily determined and the test should be made at frequent and regular intervals.

Often the fresh water supply of the mill will carry certain unsuspected impurities in solution. These impurities may be either harmful or beneficial. The preponderance of chances are, however, that they will interfere with the proper operation of the cells. Fortunately, most of the inorganic salts that occur in this way can be very easily and cheaply removed by simple chemical precipitation. Many cases have been known where the flotation plant had been built on the strength of a large amount of successful experimental work, but no successful results could be obtained until by chemical analysis of the water used in the mill circuits the presence of large amounts of inorganic salts in solution had been demonstrated. When this material had been removed by the use of lime or some other necessary reagent the mill at once commenced to produce the results that had been expected when the plant was completed.

Organic material, such as soaps, glues, decomposed vegetable matter, organic soil constituents, etc., will cause more harm in the flotation plant than the inorganic salts just mentioned. Their removal is a much more difficult proposition. If their presence can be proved to be the cause of trouble, it would be better to employ special talent to handle the situation rather than to allow inexperienced men to try their hand.

TIME FACTOR AND FLOTATION RESULTS.

The period of time during which the ore pulp is under treatment in a flotation machine is a most important factor of good flotation results. Flotation is by no means an instantaneous process. A certain definite time is required to remove the concentrate from the ore pulp. The amount of time required for this purpose depends on several important considerations, among which may be mentioned (1) the amount of pulp, in gallons, which is being treated in the flotation apparatus per minute, (2) the solid content of the pulp volume being treated, (3) the number of pounds of concentrate that must be removed from each gallon of the pulp, (4) the strength or carrying power of the froth being made on the machine, and (5) the quantity of froth being made per unit time.

It will be evident that, other things being equal, the more dilute the pulp the greater will be the velocity with which each unit of ore in the pulp will pass through the machine. Hence, to obtain the same time of treatment on the more dilute pulp will require a greater comparative length of time of treatment in the machine. When dealing with pulp dilution, however, many other factors enter into consideration and the above can only be taken as a generality.

On the other hand, a pulp must not be too dense, or the bubbles cannot rise freely to the surface. When the pulp is too dense there is the added chance that the bubbles will be scoured clean of their mineral load. the correct pulp density to fit the conditions of the case can only be determined definitely under practical operating conditions.

A froth has a certain maximum carrying power. When it is made at a definite rate per minute it can lift only a certain limited amount of concentrate. If more pounds of concentrate are contained in the pulp fed to the machine than can be removed by this froth, poor extraction of the sulphide in the ore is bound to result. When the poor recovery in the flotation machines can be definitely laid to this condition, the remedy is either to feed a smaller volume of pulp to the apparatus, to make more froth of the same character or, by means of different oils, to increase the carrying power of the froth being produced. The most satisfactory method of remedying the difficulty must depend on the ore and the other local conditions existing in the plant. These points are all matters of experiment and skill of operation.

RELATION OF GRADE OF CONCENTRATE TO EXTRACTION.

In all ore-dressing and concentration processes, the grade of concentrate produced has a most important relation to the possible extraction. A few of the more important reasons why this is especially true in flotation will be mentioned.

An observation of the froth forming on the top of the pulp in a flotation machine will clearly show that a great deal of the concentration that takes place in the machines takes place in the froth. The froth nearest to the pulp will be practically the color of the pulp, but the closer the top the froth is observed, the more nearly its color approaches that of the pure mineral that is being floated.

This effect is caused by a mechanical action that goes on within the body of the froth itself. The bubbles seem to have only a comparatively weak selective action on the sulphides in the pulp itself. This condition causes the froth, first released at the bottom of the froth column, to carry a very large amount of gangue material. As soon as the froth is out of the water, however, it commences to break up, the bubbles first formed breaking up to reform a slightly fewer number of new bubbles. During this process of reformation, the sulphides are caught on the newer bubbles formed, while the gangue is, to a large extent, forced to drop back into the pulp owing to the decreased froth surface. This action goes on from the bottom to the top of the froth column, causing the froth the greatest distance from the pulp itself to be the highest in grade.

It can be seen from this that the deeper the froth column carried on top of the pulp in the flotation machine, the higher is the grade of concentrates produced and the greater is the amount of gangue dropped from the froth into the pulp, at the same time, however, the greater is the chance for the sulphide particles to be dropped into the pulp and lost in the tailings, causing a lowered extraction.

This shows the reason for the relation between the grade of concentrate produced and the extraction possible, and, also, the principal reason for the use of one set of machines for producing the best tailing possible, and the use of another set of apparatus for recleaning the froth produced on the first machines.

PRODUCING CLEAN CONCENTRATES.

At the first of this discussion, the fact was mentioned that, in order for a plant to be successful from both a metallurgic and an economic standpoint, a good extraction of the values in the ore must be obtained, and a high grade concentrate must be produced.

The concentrate is the material that must be sold to produce the income from the milling operation. The greater the amount of valuable metal present, the more can be obtained for it, while the smaller the amount of impurities present, the fewer the penalties imposed by the buyer and the less charged for their treatment. All these considerations make it imperative to produce the highest grade concentrate economically possible.

The grade of flotation concentrates produced will depend on several factors, among which can be mentioned

(*Continued on page 48*)

"Cupping" vs. "Boxing"*

Advances in the Turpentine Industry in the Southern States

By Prof. Chas. H. Herty, University of North Carolina

[Photographs furnished by courtesy of U. S. Forest Service]

INTRODUCTORY.

A RAILWAY trip through the coastal plain of the South Atlantic and Gulf States, from North Carolina to Texas, shows on every side fallen and charred remnants of trees, stumps innumerable, and occasional huge piles of sawdust. It is a desolate scene in those sections where agriculture has not yet been developed. It represents the destructive path of the naval-stores industry, followed more or less closely by that of lumbering, through that rich, natural heritage of long-leaf pine forests which originally covered completely this entire portion of the country.

From these forests the world has received its chief supply of spirits of turpentine and rosin, averaging in value in recent years some forty or fifty million dollars annually. Yet in the production of this great crop only a very few have received for their toil more than a bare livelihood. The great mass of the turpentine operators have toiled throughout the years in rugged earnestness, in robust health from the out-of-door life in the pine forests,—but always on the outer edge of developing civilization, with few of the comforts and conveniences of life, indifferent to the utter lack of efficient business methods in their operations, and strongly wedded to woods practices which have been handed down from generation to generation as they steadily moved from North Carolina toward Texas.

If the traveller, however, should leave the main lines of travel in Florida or the more westerly States, and by tram or team reach some of the more remote sections, he would find beautiful virgin forests of this same long-leaf pine, the rich brown trunks of the trees, free from low-lying limbs, bearing aloft rich crowns of green, and firmly rooted below in a soft carpet of the same hue, formed by the "wire grass" which abounds throughout this territory.

Will the operator, in the exploitation of these remaining forests, profit by the demonstrated inefficiency of past methods? Can he change his attitude of thought toward the living tree on which his operations are based? Is he willing to place himself in line with all other lines of modern industrial life, which have realized or are beginning to realize, that true progress in any industry must be based, not upon individual opinion or hereditary teachings, but upon scientific research and constant striving for greater efficiency?

Upon the answer to these questions depends largely the future of the naval-stores industry. This is not a matter for indefinite proceeding along inefficient lines: the actual life of the industry is threatened, for the once-considered inexhaustible forests are rapidly disappearing. At the present rate of destruction the end can be fairly well forecast, especially since no effort is being made toward reforestation.

It was natural that destructive methods should have characterized this industry, for the early settlers in eastern North Carolina found forests of long-leaf pine everywhere. Clearance was necessary for agriculture, crops had to be grown, lumber was needed for industry, homes had to be built, and so the work of destruction began.

It was immediately recognized that this tree, when wounded, is a prolific producer of an oleoresin, "crude turpentine." Furthermore, the rich resinous wood, when heated out of contact with air by piling in heaps and covering with earth, gave off a rich distillate of tar, which could be boiled down to a pitch. These products, tar and pitch, were much needed for the wooden ships with their extensive rigging, at that time universally in use; and so along with agriculture, with its yearly crops, there developed the naval-stores industry with its constant output of immediately marketable products.

The method of conducting the industry called for no plant other than the forests, and so when the yield of the trees began to decrease after two years of operation, new tracts were opened, and the industry began its march southward, from North Carolina into South Carolina, thence into Georgia and Florida, and then rapidly expanding into the Gulf States, though on a smaller scale.

Windfalls, the result of severe boxing

In the early days in North Carolina no effort was made to separate the crude turpentine by distillation into its constituents, spirits of turpentine and rosin, the gum being shipped to Northern cities or to England for such manufacture. In the early part of the past century, however, this manufacture was transferred to the woods, iron stills being at first employed, which later were replaced by the more efficient copper stills such as are used today for this purpose.

METHODS OF COLLECTING GUM.

In the woods, however, there was no corresponding advance in methods of operation, with the exception of slight improvement in the tools employed. Thus for more than a hundred years the method of wounding the tree and collecting the gum remained the same throughout the turpentine belt.

Round or un-tapped long-leaf pine

The normal routine on all turpentine farms consisted of the following operations:

"Boxing."—In the winter negro laborers, under the direction of a white woodsman, cut "boxes." The box was an elliptical cavity cut in the base of the tree, usually just above the junction of a prominent root with the trunk of the tree. It served to collect the gum which flowed during the warmer months from the scarified surface above. The tool used in cutting this box has a very long, narow axe, the negroes developing consummate skill in the use of this "box axe." The standard dimensions of the box were 14 inches width, 7 inches depth, and 3½ inches from the outer wood toward the center of the tree. The number of boxes per tree was increased from one to four, and occasionally five, according to increasing diameter of the trees.

"Cornering."—Box cutting was followed by "cornering." This consisted of removing two triangular chips from immediately above the box by means of the usual wood-chopping axe. The function of cornering was to provide smooth surfaces to direct the flow of the gum into the box.

"Chipping."—As vegetation became active in early spring the work of scarification of the trunk of the tree began, and continued weekly for eight months. The repetition of this process was necessary, as the flow of gum, greatest during the first three days following the fresh chipping, practically ceased after one week. The tool employed in chipping, called a "hack," was a stout U-shaped steel blade attached by a metal shank to one end of a round wooden handle. This handle carried on its other end a heavy iron weight which gave momentum to the free arm stroke used to draw the blade through the bark and outer sapwood (shown in Fig. 6). A slightly modified form of this tool, called the "puller," was mounted on a much larger handle, with no iron weight attached, and was used for the higher reaches of the third and fourth year of scarification.

"Dipping."—At periods of four to five weeks, when, in the judgment of the woodsman, the boxes showed an average filling, the gum was removed into buckets by a broad, flat, spear-shaped tool, called a "dip spoon." Barrels placed at convenient distances in the woods received the gum from the buckets, and were then hauled to the "still" for distillation.

"Scraping."—As the chipping season progressed not all of the gum found its way to the box, for as crystallization of the gum began some of this mass remained sticking to the exposed surface of the tree. At the close of the chipping season this accumulated resinous mass was scraped from the trees, giving thus the name, "scrape," to the product. Its content of spirits of turpentine was much lower than that of the gum from the boxes.

"Raking."—With the completion of the scraping, the final operation was the protection of the trees from the ground fires which prevail throughout the turpentine belt in late winter when the dead wire grass is burned. Such protection, "raking," was effected by means of a common hoe, all combustible material, chips, pine needles, and dead grass, being removed to a distance of about two feet from the base of the tree.

This completed the year's operations in the woods, and the cycle was then renewed from year to year.

WASTEFULNESS OF "BOXING" METHOD.

The severe strictures on the wastefulness of the industry spoken by the German technologist, Otto N. Witt, led to the determination on the part of the writer to investigate whether or no this criticism was deserved. Correspondence with men familiar with the industry, and a brief visit to a turpentine farm in South Georgia, afforded ample proof that conditions were even worse than had been depicted.

With such waste prevalent, could not something be done to improve the situation? Here the methods of work learned through research in a chemical laboratory asserted themselves. A search of the literature was begun and made as comprehensive as possible. The result of this study and of observations in the woods made clear the fact that the great evil of this industry, that which more than all else was responsible for the waste and destruction, was the cutting of the "box" in the base of the tree. This deep cavity, located just where the strain was greatest, caused many of the trees to fall in even slight windstorms. It constituted a great source of danger during fires, especially after turpentine operations had ceased and the tree no longer was protected by the annual "raking." The decreased vitality of the tree, due to the severe wound, led in

*Reprinted from *Journal* of *Franklin Institute*, (Philadelphia).

Chipping the first "streak" | Cutting the "box" | Cornering the box

many cases to easy attack by injurious insects. Such evils were easily noticeable, but others, less readily seen, were found upon closer study. With a receptacle at a fixed point, while the distance between the receptacle and the freshly-chipped surface increased regularly from week to week, opportunity was thus afforded for increasing loss of the volatile oil by evaporation, for coloration of the rosin by absorption of oxygen from the air under the influence of sunlight, and for waste in dripping outside the box. It seemed reasonable, moreover, that this severe wound would so decrease the vitality of the tree as to cripple, at least to some extent, the power of the tree to produce crude turpentine. The "box," therefore, should be the primary point of attack in any effort to conserve these forests.

"CUPPING" SYSTEM DEVISED.

To overcome the evils of the "box," a substitute receptacle must be provided which should inflict but a slight wound in placement on the tree; should be capable of removal at convenient intervals to a point just below the chipping surface; should be extremely simple in its construction, in view of the gummy character of the product it was to receive; easy of operation, because of the unskilled labor which would use it; and cheap, if hopes were to be entertained of its commercial introduction by those who were abundantly satisfied with existing methods and fully convinced that no better could be found—an unfortunate state of mind in these days of progress.

The literature of the French system of turpentining was then studied, and the records of the Patent Office were thoroughly searched. Nothing, however, was found quite free from objections to its ability to meet the above requirements, especially as applied to the system of chipping as practised in the Southern States. In the light gained from this study, however, a substitute was devised, consisting of a simple cup suspended through a hole near its rim, on a common nail. Into this cup the gum was to be directed by two shallow galvanized iron troughs or gutters, to be inserted about one-quarter inch deep by one of their long edges in correspondingly shallow inclined cuts across the scarified surface of the tree.

EXPERIMENTS IN "CUPPING."

With this apparatus provided, and again following the procedure of laboratory research, preliminary experiments were begun, during the summer vacation of 1901, in the forests of southeast Georgia, near the town of Statesboro, on timber provided, after much persuasion, by some of the leaders of the industry in Savannah, Georgia, who viewed their concessions with an eye of infinite skepticism.

The results of these preliminary experiments were the thorough demonstration of the efficiency of the apparatus, a deeper grasp of the problem to be solved, a genuine sympathetic interest with the personalities of many employed in the industry, and much knowledge of the habits of the pine. It was completely demonstrated that the dark color of rosin produced under the box system, after the first year of operation, was not at all due to physiological changes in the pine, but solely to the method of collecting the gum. Under this system opportunity was offered for increased oxidation and for absorption of the deeply-colored gum coating the exposed surface, formed by the chipping of previous years. This latter point was important, as the commercial value of the rosin decreases as the depth of color increases.

Gutters and cup in position; virgin (right) and at end of the first year's chipping (left)

The United States Bureau of Forestry, hearing of the proposed preliminary experiments, tendered the writer a collaboratorship in order to secure publication of the results. The experiments were so full of promise that it was agreed that the work should be promptly resumed at the opening of the next season, with field experiments on a commercial scale, under the auspices of the Bureau of Forestry. Accordingly the experiments were begun in February, 1902, on the turpentine farm of Powell, Bullard & Company, a well-known firm operating in southeast Georgia, near the town of Ocilla.

For these experiments the following policy was adopted at the outset:

First, the timber was to be provided by the firm; the cups and gutters and cost of installation, by the Bureau.

Second, the labor was to be none other than such as was employed in the regular work of the farm.

Third, the experiments were to be restricted solely to the "box" question and the practicability of the substitute cup and gutters. Therefore the work of chipping, dipping, and scraping should be conducted in the normal way.

Fourth, four sets of comparative experiments were to be conducted simultaneously, one on virgin timber, and three on boxed timber which had already been operated respectively one, two and three years. This would determine, so far as possible in one year, the influence of the box on the timber and on the income of the operator.

Fifth, the results should be taken from the records of the company, whose statements would be readily accepted by all other operators.

So far, so good. Then troubles began. The manufacturer, delayed in his work, did not deliver the equipment until the chipping season was nearly at hand. This led to shortcomings, undreamed of at the time, and which in after-years caused the loss of many thousands of dollars; but this will be discussed later. Next, labor troubles were unexpectedly encountered. The negro laborer proved even more conservative than the white operator and woodsman, and assumed the remarkable attitude that the "flower-pot" method of making turpentine was more properly the work of women and children, and not suited to the dignity of full-grown men. This may be difficult of belief, and it was strange in the light of later developments, but it proved a serious obstacle for some time. By dint of patience, tact, and kindly reasoning this trouble was at last overcome sufficiently to enable a beginning of work in the woods with three laborers, but up to the very moment of actual handling of the axe the chagrin and mortification of those three negroes, too inefficient for the regular box-cutting squad, were comical, though the situation had its serious side in that the whole question of the carrying out of the experiments became more and more marked the comical picture then became the rather haughty air and proud demeanor of those who gleefully dubbed themselves "cup niggers!"

"BOXING" VERSUS "CUPPING."

To return to the experiments: three crops were selected, consisting each of 10,000 boxes, the unit of operation. These three had already been under operation one, two and three years respectively. On one-half of each of these crops cups and gutters were installed near the point where the chipping would begin. On the other half the gum was collected in the normal way, in the box, at the base of the tree. These experiments would determine the practicability of the equipment at varying heights on the tree; the quality, as to color, of the rosin produced from gum collected under

the two systems; and would give some information as to relative waste from evaporation, etc.

The main interest, however, centered in the experiment on virgin timber, where the two systems could be put into operation under fully equal conditions. For this experiment a tract of timber of fair average quality was selected by the firm just outside of the town. To insure accuracy of the experiment, this timber was carefully and repeatedly cruised by experienced woodsmen, and a division made as to location of cups and boxes respectively. In this division it was decided to alternate the "drifts" (subdivisions of a crop) of cups and of boxes. This also furnished more uniform weather conditions in working the two halves. The entire crop was to be chipped by one man, and the dipping was to proceed every three weeks simultaneously in the cupped and boxed halves of the crop, the gum to be collected in different sets of barrels. The presence of varying amounts of trash and water would render inaccurate the results from measuring or weighing the gum. Therefore it was distilled and record kept of the number of gallons of spirits of turpentine obtained from each lot, and separate sales made of the rosin produced. No difference in quality of rosin was expected or found here. As the distance of flow of the gum was the same in each set, loss of spirits of turpentine by evaporation was equalized. All precautions were taken so that whatever difference of results might be found in the yields from the two halves could be ascribed to no other factor than the influence of the severe wound caused by box cutting on the productive power of the trees. The advancement of the idea that it decreased productive capacity had met with hoots and jeers on all sides; and here in this crop, it was felt and stated without the least effort of repression, would be demonstrated the superiority of the judgment of the "practical" man over the theoretical college professor.

The work of installation began. Two flat faces meeting in a central line were cut with common axes to adapt the round tree to the straight-edged gutters, two laborers with broadaxes made across these plane surfaces the incisions for the gutters, which were promptly inserted by another group of laborers, the upper gutter reaching just to the center of the face and emptying into the opposite gutter equally inclined, running about one inch lower and extending about two inches beyond the angular center of the face, to provide a suitable hanging of the cup into which all of the gum dripped. While awaiting the arrival of the cups and gutters, the box-cutting squad and the "cornerers" had been gleefully at work in the other half of the crop.

With the respective receptacles provided and installed, the work of chipping began—and the race was on. The detailed results are given in Table 1.[1]

TABLE 1

First-year Crop—Dippings.

Number of dipping	Date of dipping		Number of chippings	Barrels of dip obtained		Spirits of turpentine on distillation (gallons)		Excess spirits of turpentine (gallons)	
				Boxes	Cups	Boxes	Cups	Boxes	Cups
1	April	14	3	9⅝	17⅝	101.6	84.3	17.3	...
2	May	5	3	9⅛	10⅛	111.0	130.5	....	19.5
3	May	26	3	12	14⅛	136.8	178.3	....	41.5
4	June	16	3	12⅛	17⅛	143.3	191.2	....	47.9
5	July	7	3	12⅛	14⅝	142.4	175.2	....	32.8
6	July	28	3	10⅛	12⅜	115.2	141.7	....	26.5
7	August	18	3	10	11⅝	106.6	126.6	....	20.0
8	September	8	3	8	10⅛	86.1	105.9	....	19.8
9	September	29	3	7⅝	9⅛	80.3	106.0	....	25.2
10	November	4	5	10⅛	12⅜	110.9	145.6	....	34.7
Total	.....		32	101⅝	121⅝	1,134.7	1,385.3	17.3	267.9

* Including resin from box cutting and cornering.
† Including resin from placing cups on trees.
‡ Boxes dipped after trees have been scraped.

The unexpected shortage from the cups on the first dipping led to great rejoicing among the box support-

[1]The tables throughout this paper are from Bulletins 40 and 90 and Circular 34 of the United States Forest Service.

Removing hard resin (scrap) at end of 2d-year box

ers, and to undoubted apprehension on the part of the solitary backer of the cups. The second dipping, however, altered the situation, and by the last of June the victory for the cups was so complete that all were converted. The beginning of the end of the box system had been reached. From this point on all went well. Labor was anxious to enlist, enthusiasm had supplanted scoffing, and now the chief effort of the original cup backer was to guard against possible inflated

Third-year boxed timber with cup system

results, due to some over-zealous convert, which results might not be justified by the facts in the case, for in spite of convictions formed in advance of experiment it was, as in all research, the truth which was sought.

Several years passed, much thought was expended, and many experiments were made before the true interpretation of that shortage on the first dipping was obtained and its remedy provided. This will be discussed later.

Meanwhile the distillation of the gum from the second-, third-, and fourth-year crops showed uniformly high-grade rosin from the cups, as contrasted with the low-grade rosin from the corresponding boxes, and the equipment proved itself readily adaptable to the increasing heights of chipping.

The results of net rosin sales from all four crops are given in Table 2.

TABLE 2.

Season's Record of Net Rosin Sales.

Half crop	From dip	From scrape	Total	Excess net sales	Per cent. excess net sales cupped trees
First year:					
Cups	$401.72	$47.72	$449.44	$85.51	23.50
Boxes	328.40	35.53	363.93	.....	.....
Second year:					
Cups	266.34	49.25	315.59	144.13	84.64
Boxes	104.51	66.95	171.46	.....	.....
Third year:					
Cups	171.27	27.44	198.71	132.65	200.80
Boxes	59.49	26.57	66.06	.....	.....
Fourth year:					
Cups	167.33	29.23	196.56	132.56	207.13
Boxes	36.09	27.91	64.00	.....	.....

The experiments with the second-, third-, and fourth-year crops were discontinued at the end of the year, having served their purpose. The working of the virgin crop, however, was continued two years longer. The complete results for the three years' operation of this crop are given in Tables 3, 4 and 5.

TABLE 3.

Spirits of Turpentine from Half Crops.

Year	Cups			Boxes			Excess from cupped half crop	Net price per gallon at time of operation	Value of cup excess
	From dip	From scrape	Total	From dip	From scrape	Total			
	Gallons	Gallons	Gallons	Gallons	Gallons	Gallons	Gallons	Cents	
First	1,385.3	205.0	1,590.3	1,134.7	153.7	1,288.4	301.9	40	$120.76
Second	1,103.5	165.0	1,268.5	705.2	220.6	931.8	336.7	45	151.52
Third	781.3	136.0	917.3	536.1	190.5	726.6	190.7	45	85.82
Total	3,270.1	506.0	3,776.1	2,376.0	570.8	2,946.8	829.3		358.10

TABLE 4.

Net Sales of Rosin from Half Crops.

Year	Cups			Boxes			Excess from cupped half crop
	From dip	From scrape	Total	From dip	From scrape	Total	
First	$401.72	$47.72	$449.44	$328.40	$35.53	$363.93	$85.51
Second	286.88	58.24	345.12	132.42	84.08	216.50	128.62
Third	212.60	61.65	274.25	124.76	79.70	204.46	69.79
Total	901.20	167.61	1,068.81	585.58	199.31	784.89	283.92

TABLE 5.

Summary of Gain from Cupped Half Crops.

Years	Spirits of turpentine	Rosin	Total
First	$120.76	$85.51	$206.27
Second	151.52	128.62	280.14
Third	85.82	69.79	155.61
Total	358.10	283.92	642.02

Total Value of Products from Three Years of Operation.

Cupped half crop	$2,688.55
Boxed half crop	2,046.53
Gain from cupped half crop	642.02 = $1,284.04 per crop.

That the distribution of the timber in this virgin crop had been well equalized was shown by measurements of diameters of all trees in the crop and by a determination of the average number of cups or boxes per tree throughout the crop.

Effect on Tree-vigor.—As the work progressed, careful record of the dead and down trees were made in each half. The count at the end of the three-year period is shown in Table 6.

During the chipping season portions of some of the chipped surfaces became unproductive, locally termed "dry face." The results of the measurement of the extent of "dry face" in the two halves of the crop showed an excessive amount in the boxed half at the end of the first year. From that time on the amounts, while increasing in each, showed less striking difference.

(To be continued)

Turpentine still at Ocilla, Ga.; and hauling crude resin from the orchard to the still

Acquired Radioactivity

By Sir William Crookes

[CONCLUDED FROM SUPPLEMENT No. 2270, P. 15]

31. AFTER repeated observations on the action of radium on various substances, it was seen that diamond behaved differently from glass, quartz, and other materials, especially if the action of the radium had been continued for some length of time. The following experiments were made to see if definite light could be thrown upon this point. Some plates and crystals of pure quartz, lead glass, Faraday's borosilicate lead glass, and three diamonds were selected —well cleaned, and exposed upon a sensitive film for twenty-four hours. On development it was seen that all were inactive, except in the case of two of the diamonds, but from these the action was so slight as to be only just visible upon the film. These objects were now laid upon a table of clean platinum gauze and enclosed in an air-tight vessel, together with an open bottle containing pure radium bromide. They were allowed to remain exposed to radium emanation (33) for forty-eight hours; they were then removed from the chamber and laid upon a sensitive film for twenty-four hours. Upon development each object was found to be active and there was nothing to show that the three diamonds had acted differently to the quartz or glass. The objects were now all boiled in dilute nitric acid and thoroughly washed in clean water. They were placed on a film and allowed again to remain for twenty-four hours; on development it was seen that practically the whole of the "activity" had been removed—the two diamonds that originally were very slightly active had, perhaps, gained a little, but all the other objects had lost their temporary activity.

32. The experiments were still further extended. Two fragments of lead glass and one diamond crystal that had been buried in radium for over two years and had become deeply colored, the diamond green and the lead glass brown, were removed from the radium and cleaned as far as possible with a dry brush. They were kept upon a film for five days. On development the photograph showed three equally dense black patches. The glass and diamond were now boiled in dilute nitric acid, thoroughly washed, laid upon a film, and kept there for eighteen hours. Upon development the pieces of glass were seen to have almost lost their activity—the diamond gave a dense black impression. The objects were now placed in a mixture of fuming nitric acid and potassium chlorate and kept just short of boiling-point for six hours, frequently removing the weakened solution and adding fresh acid and chlorate (3, 9, 12); they were then thoroughly cleaned, dried, and laid upon a film for eighteen hours. On development the glass blocks gave impressions slightly fainter than before, while the diamond still gave a dense black image almost as strong as before the treatment.

33. An examination with a zinc-sulphide screen showed that the diamond caused brilliant scintillations from its edges and corners and a few erratic scintillations could be detected round each of the fragments of glass (11, 17, 26, 27, 30). The net result of these experiments is to show that, although the well-known condensation of emanation (31) upon crystals and objects gives rist to photographic markings of patterns as described in this research and in previous papers by Sir Ernest Rutherford ("Distribution of the Intensity of the Radiation from Radio-active Sources," *Phil. Mag.*, August, 1906) and other observers, this superficial activity can be easily and completely removed by washing in dilute acids. The diamond crystal—that had been rendered active by immersion in dry radium bromide for some months in 1906 (17) and has been treated with acids, heated, and used in hundreds of experiments since—is apparently as active now as when it was removed from the radium, and still pours out streams of α-rays.

(These experiments are closely connected with those of Swinton, Colley, Ramsay, and others, who have shown that helium is driven into the glass walls of a vacuum tube even by the slower moving cathode rays. The high speed α-particles evidently are driven into the diamond, below the molecular surface.)

34. As in the case of diamond, a quartz glass dish after the action of radium retains its color and activity, and continues to give off α-, β- and λ-rays One-half had a film of aluminum, 0.035 mm. thick, interposed between the dish and the sensitive plate. Vessels of pure fused silica that have been much used for the crystallisation of radium salts become colored a purplish tint, similar to that assumed by soda glass in similar circumstances. On heating such a colored vessel with a spirit lamp to a temperature much below a red heat it suddenly phosphoresces a bluish color and at a red heat becomes colorless.

35. A small equilateral prism was cut from a block of heavy glass (sp. gr. 3.87), polished on its three refracting faces, but left rough ground on the triangular top and bottom. It was put into a bottle and covered with dry crystals of radium bromide for fifteen hours. At the end of this time it was removed, well washed, and placed on a sensitive film, base downwards, for twenty-two hours. On development a strong action was apparent with overflow radiation along the sides and the continuation of the faces in triangular lines, as observed by Sir E. Rutherford.

36. One of the rough ground bases of the prism was now polished over the greater part of its surface, leaving a strip of glass along one edge in its original unpolished condition. This end was then laid on a sensitive film for thirty-six hours. On the polished portion of the surface there was absolutely no perceptible action on developing, while the part left unpolished was highly active—as in the first experiment with the prism.

37. The prism was now laid on a sensitive film on one of its polished faces for twenty-four hours. On development slight action was observed where the polished face touched the sensitive surface and a much stronger overflow action with continuation of the edges of the prism face in straight lines as mentioned above.

38. The same prism was taken, and a diagonal scratch made with a writing diamond across the same face that touched the film in the last experiment. It was laid with this face downwards on a sensitive film for twenty-four hours. On development the image showed action as before where the face touched the film, but the line of scratch where the surface of the glass had been abraded by the diamond was blank, showing no action whatever.

39. A triangular plate, about 1 mm. thick, was polished on its three edges, and kept in a bottle of solid radium bromide for sixty-eight hours, then laid on a sensitive film for four hours. There was very little action to be seen on development on the part where the face touched the film, but there was strong action radiating from the edges, with a continuation of the line of edge from each point. The plate was now cut into two equal parts, and the two halves, separated about a centimeter, were laid on a sensitive film and there kept for forty-eight hours. On developing, it was seen that the action of the flat surface was the same as before, but while the overflow action from the original corners was also the same, there was no action at all along the cut surface.

40. A glass tube that had contained 25 mgrms. of radium bromide was cut in half to remove the radium, and well washed and boiled in acids. It was of a dark blue color. After being in a cabinet for many months the two halves were laid on a sensitive film in a line, the cut surfaces opposite each other and separated about 2 mm. After four hours' contact the film was developed, when the appearance presented that of a streaming brush discharge from the two ends of each half—the part where the tubes themselves rested having made no impression.

SUPERFICIAL ACTION OF RADIUM ON MICA.

41. Radium bromide has been imported from the Continent in small ebonite boxes covered with a disc of mica. One of these discs was first well washed to remove any adhering grains of radium salt—it was then split into four flakes. The upper flake, of a strong brown color, discharged the electroscope in three seconds. The next film, also showing brown discoloration, required 3.5 seconds. The third film, not discolored at all, required twelve seconds, while the last film, which had been furthest from the radium, required eighteen seconds for discharge, showing that the greater part of the activity was near the surface and corresponded with the coloration.

ACTION OF X-RAYS ON DIAMOND.

42. Experiments were instituted to ascertain how X-rays affected the diamond. A tray full of crystals of diamonds was exposed to X-rays from a hard tube, covered in card and velvet so as to prevent interference from the luminosity of the glass. Most of the stones became luminous—but in different degrees. Two stones specially were noticed. One large stone shone very brightly, with a blue tint, the other, smaller, was only just luminous. A sheet of aluminum, 3.2 mm. thick, was now interposed in the path of the X-rays, when the phosphorescence of the large bright stone was considerably reduced, while that of the small faint stone was not diminished at all.

ACTION OF β-RAYS ON DIAMOND.

These two diamonds were subjected to the action of solid radium bromide, and the intensity of the phosphorescence thereby induced was seen to be of the same character as that caused by the X-rays. An extension of the experiment with radium, described in the next paragraph, showed that the effect of phosphorescence was mostly due to the β-rays (10, 19, 26.)

43. An apparatus was fitted so that the active rays from a bottle of radium bromide should pass through a tube drilled through a lead block and allowed to pass upwards on a diamond supported on a plate of aluminum, 0.02 mm. thick. This was arranged between the poles of a powerful electro-magnet, so that the active rays from the radium should pass through the hole and act on the diamond when the magnetism was off, and be deflected from it when the magnetism was on.

A screen of barium platinocyanide put over the hole in the lead block showed a circular spot of phosphorescence. This luminosity vanished when magnetism was turned on, and reappeared when it was turned off, showing that the luminosity on the screen was chiefly due to the β-rays (10, 19, 26). The two large and small diamonds used in the last experiment were put side by side on the aluminum, and the support so arranged that it could be moved sideways to put either stone over or away from the hole in the lead block. It was easy to see by small movements of the support that, as in the case of the X-rays, the large stone was much more phosphorescent than the smaller stone. There was considerable residual luminosity, each of the stones continuing to glow with its relative intensity when effectually removed from the radium. Having found the position of maximum brightness for the large stone when over the radium, the current was turned on, so as to deflect the β-rays. At once the glow declined, and the residual phosphorescence faded. On taking the current off, so as to allow the β-rays again to come into action, the brilliancy increased again. There was no doubt as to the action, although the undeflected γ-rays and the residual luminosity tended to obscure the observations.

44. The results described in this paper may be summarized as follows: Various objects, diamond, ruby, garnet, quartz, gold, platinum, etc., also the phosphorescent substances yttria, calcium sulphide, zinc blende, and barium platinocyanide, are bombarded in a high vacuum by cathode rays, and in no case can any permanent activity be recognized either by photographic or electrical means (1, 2, 3, 4, 5, 6, 7).

Exposure to radium emanation confers temporary radio-activity on all bodies that have been tried; apparently due to the condensation of the emanation on the surface. This transient activity can be completely removed by washing in dilute acids (31).

Many substances become colored by direct exposure to radium, the color depending on the substance. Diamonds take a full sage-green tint, the depth depending on the time of exposure to the radium (33).

In addition to change of color diamond also becomes persistently radio-active, continuously giving off α-, β-, and γ-rays. The acquired color and activity withstand the action of powerful chemical agents, and continue for years with apparently undiminished activity (12, 31, 32).

Removing the surface by mechanical means removes both color and radio-activity (13, 16, 35, 37, 41).

The appearance of an auto-radiograph made by placing an active diamond crystal on a sensitive photographic plate, and the visual examination of its "scintillation" luminosity, suggest that there is a special discharge of energy from the corners and points of the crystal (18, 21, 23, 27, 33).

Antarctic Ice-Cap

D. MAWSON finds that much of the foundation of the Antarctic ice-cap is elevated land, but elsewhere its floor is below sea-level. The ice surface masks a very irregular rock basement, and the ice thickness is, therefore, variable, and may reach several thousand feet. The mechanics of the flow and abrasion of so large a mass is different from that of smaller flows. The static pressure at the base may reach one ton per sq. in., and the accumulation of ground-heat may raise the temperature considerably above that of higher zones. When, therefore, ice is very thick a plastic base must be admitted. Where the supply is less than the destruction at the sea front, the ice boundaries are approximately the true coast line. Exceptions to this prevailing condition are the Great Ross Barrier and the Shackleton shelf, where the overflow from the land maintains itself as a thick floating structure extending far out to sea, and known as "shelf-ice." At the present rate of advance, ice at the sea face must have left the center during the seventh century.—*Science Abstracts.*

Recent Developments in Marine Lighting—III*

Methods of Sound Signalling

ALL the systems in use for unattended lights combine with the lighting apparatus some method of sound signalling, the whistling buoy being one which has found considerable application. An air chamber is formed in the center of the buoy and is connected with the sea by means of a tail pipe of mild steel. In this pipe the imprisoned air is compressed by the action of the waves and operates a whistle placed inside the structure which supports the light, the necessary air inlet pipes with self-acting non-return valves being provided. The usual type of whistling buoy is the Courtney. From the lower end of this buoy a large tube descends about 30 ft., the object being to reach a depth where the water is unaffected by surface movements; inside the tube the water rises to the mean level of the sea. As the buoy rises and falls by the action of the waves, there is produced an alternate inhaling and exhaling of air; this air is made to impinge on the edge of a whistle which produces a loud deep sound heard, under favorable circumstances, over a distance of five miles. An alternative design is the bell buoy, but it is not nearly so efficient as the whistling type.

There are several methods of operating fog signals on beacons. It is now five years since an automatic acetylene fog gun was introduced at Dhuheartach Lighthouse. This gun is claimed to have great advantages over the ordinary tonite explosive signal. It is entirely automatic and fires as frequently as four times every minute, whereas the tonite apparatus can hardly fire more often than once in five minutes and requires constant attendance. Two fog guns have been installed on the Clyde at Roseneath Beacon and at Fort Matilda Pier, the operating station being at Gourock Pier. Wireless methods of operation are adopted. The relative positions of the transmitting station and the points where the fog guns are installed are shown in the accompanying map, Fig. 1. When fog appears, an aerial at Gourock, by a series of sparks transmits energy to aerials on the beacon and at Fort Matilda, thereby completing the circuits of the local batteries. This operation switches on the fog signal. The guns once they are set in action work automatically, giving reports at predetermined intervals, which can be heard in favorable weather over a distance of three miles. The guns are supplied with acetylene in measured quantities, the gas being mixed with the necessary proportion of air to produce a good explosive mixture. This application of wireless to other than communication purposes is an important step in the field of marine lighting and signalling. A small optical apparatus only is erected on Roseneath Beacon, which is primarily intended to carry a fog signal, but a gas-lighted buoy has been placed at the edge of Roseneath Patch.

It would seem that there is an opportunity for establishing a considerable British industry in the manufacture of welded buoys, which before the war were made almost entirely in Germany.

A good deal of work has been done recently in the development of the unattended lightship, chiefly up to the present in Scotland and France. One of the earliest unattended lightships, if not the earliest, was laid down at the Otter Rock by the Northern Lighthouse Board. These ships are more effective than buoys, as they carry a more powerful light at a greater elevation, while the large expense of a lightship manned by a crew is avoided. The vessels cost at pre-war prices £3,000 apiece, while an ordinary attended lightship costs about £12,000, and the maintenance is reduced from £1,500 per annum to a mere fraction of this sum. They cannot, however, give so effective a fog signal as can a fully manned lightship. These unattended vessels have hitherto chiefly been illuminated by means of compressed oil gas.

The Australian Government has just had constructed four unattended lightships to the design of Messrs. D. and C. Stevenson, Edinburgh. The type of vessel for this service is shown in Fig. 3. They are specially designed for very exposed situations on the Queensland coast, and are illuminated by means of dissolved acetylene. The vessels are equipped with bells rung by the motion of the ship and have optical apparatus, giving a group flashing light of 1,500 candle-power with three flashes in quick succession every 15 seconds. The lighting apparatus—see Fig. 2—is supported in a gimbal frame which allows of a swing of 45 degrees from the vertical on either side. The gimbal is fitted with ball bearings for the trunnions, and is secured to a cross girder attached to the framing of the lantern roof. The trunnion bearings are fitted with locking pins for use when required. The lantern is 5 feet in diameter inside the glazing. The framing is of gun-metal of the helical type, the roof being of copper. The lower portion of the lantern is constructed of mild steel plates and angles, and is fitted with a steel door for ingress from the external gallery. Bird screens of copper wire netting are fixed to the outside of the glazing. The lanterns have been specially designed for service in the cyclone area, and particular care has been made to prevent cross and down draughts, so that the pilot lights of the burner may not be extinguished. Owing to the prevalence of very minute insects, every opening of the lantern is covered with the finest copper wire gauze. The high pressure tubing from the acetylene cylinders to the lantern is of mild steel, tinned on the interior and is connected to the flasher by a length of rubber tubing. A pressure reducer is fitted between the rubber tube and the steel pipe. The intensity of the beam from an apparatus of this type with a three-jet burner is about 1,500 candle-power.

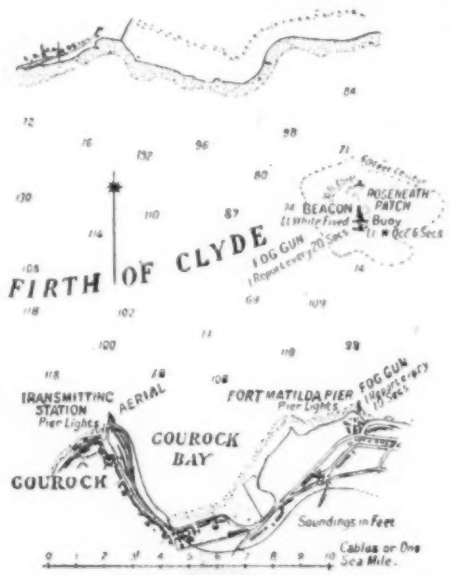


Fig. 1—Distribution of fog guns in the Firth of Clyde

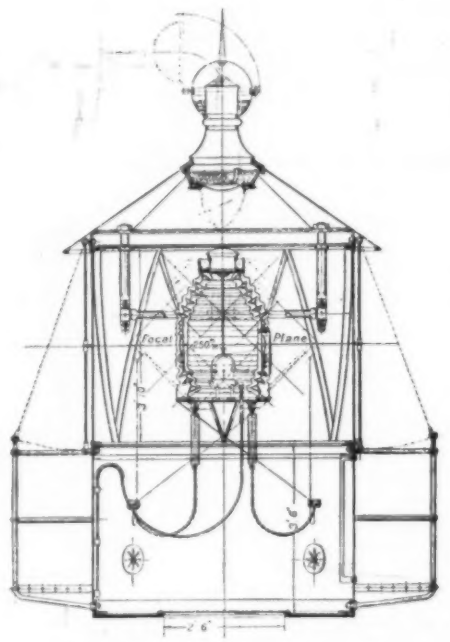


Fig. 2—The lantern apparatus on the Queensland lightship

Fig. 3—The unattended lightship used by the Australian government off the coast of Queensland

The Aga pendulum lens for an unattended lightship is illustrated in Fig. 4. The spindle of the lantern is carried by a universal joint provided with ball bearings in place of the edge bearings generally used. The upper balance weight is carried upon special bars which, without interfering with the light, relieve the lens frame of all stress. The main object of the pendulum is to secure a large moment of inertia, in order to obtain as long a period as posible, and to prevent the oscillations of the lantern coinciding with the motion of the vessel. Thus the lower balance weight is made adjustable in the vertical direction, and at the same time it is also adjustable in a horizontal direction, in order that the spindle shall hang absolutely vertical.

Incandescent oil burners on comparatively a new system have been introduced to replace compressed oil gas or acetylene in light vessels, the effect being not only largely to increase the candle power, but to effect economy in first cost and in expense of upkeep.

In addition to the unattended lightship, the unattended lighthouse and fog signal is also a feature of recent practice. There are many of these installations now working, that at Platte Fougère, which was described in *The Engineer* for April 8th, 1910, being probably still the best example of the kind in existence. This light is placed in the Little Russel Channel at the entrance of St. Peter Port, Guernsey, on an isolated rock known as Platte Fougère, where the prevailing conditions preclude the posibility of keepers living in the tower. The light is an automatic acetylene gas plant, the gas being stored in cylinders and the light turned on and off by a clockwork arrangement. The fog signal is electrically operated, current being supplied from the shore by means of a submarine cable. The fog signal is the important part of the project, the light being quite subsidiary. The experience gained with this installation has shown that for inaccessible situations where a sound signal and light are necessary, the method followed is particularly suitable, while the cost is quite small in comparison with that of a lighthouse establishment.

*From the *Engineer*. For I and II see Nos. 2266 and 2268, respectively, of SCIENTIFIC AMERICAN SUPPLEMENT.

French and German Roller Weirs

THE accompanying illustration shows the construction of the roller weirs developed at Augsburg-Nürnburg, having special features and advantages claimed to be of great value. The main body of the roller weir consists in its fundamental form of a watertight cylinder built up of riveted steel plates like the drum of a steam boiler. When the dam is to be opened it is rolled up on inclined rails which are supported in lat-

eral recesses in the masonry piers, by means of a chain which encircles one end of the cylinder. The uniform advancement of the two ends of the cylinder is ensured during winding by toothed gearing, arranged at each end and consisting of a toothed rim which engages with a rack fixed on the masonry.

The lifting chain is driven by winch gear. Instead of being circular, the main body of the weir can have any other shape best suited to the special conditions which obtain, as it is sufficient when only the ends are constructed suitable for rolling motion.

It is claimed that the main advantages of the roller weir include: the possibility of constructing sluice openings of a very large clear width and height without intermediate piers of great importance is its applicability to rivers carrying large quantities of detritus and in which the ice conditions are unfavorable.

There is also the possibility of opening or closing very large sluices in a short time as well as great durability and stability of construction and extremely small resistance to motion with simple attendance. It has a high degree of safety of operation with efficient water tightness and low maintenance costs.

Sector weirs have also been used extensively abroad. The weir in the river Weser, near Bremen, is the first weir of the sector type built on the principle of the Lockport weir (Chicago Drainage Canal) in Germany. The two gates are each 177 feet long and 15 feet high. The sectors which run around a pivot running the whole length of the weir can be lowered into a pit in the river bed and are operated by suitably regulating the pressure of the water in the pit and inside the sector.

Other roller weirs of interest are to be found at various points in Europe. The French roller weir at St. Michel, Savoy, on the River Arc has a length of 30 meters (95 feet 5 inches) and a height of 3 meters (9 feet 10 inches). The German roller weir at Trostberg, Alsace, has a length of 15 meters (49 feet 3 inches) and a height of 3 meters (9 feet 10 inches).

On the whole, it appears that this type of construction, unusual as it is in America, is a familiar feature of European hydraulic engineering.

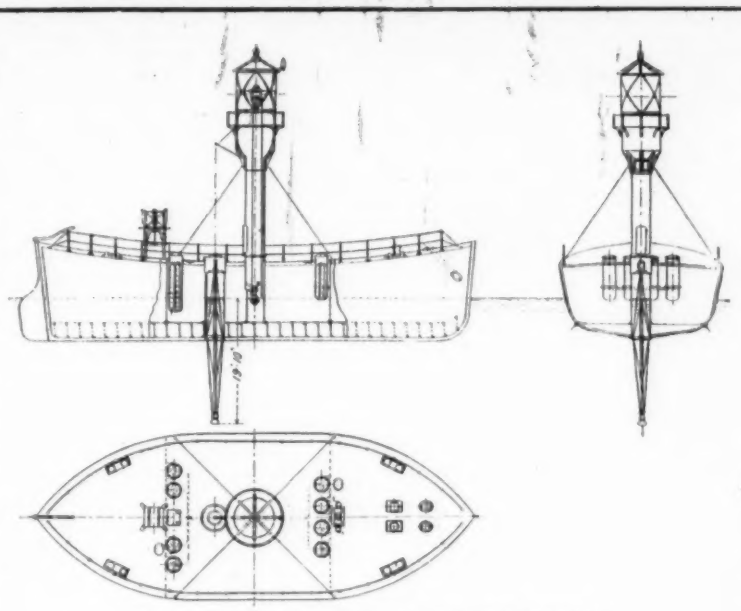
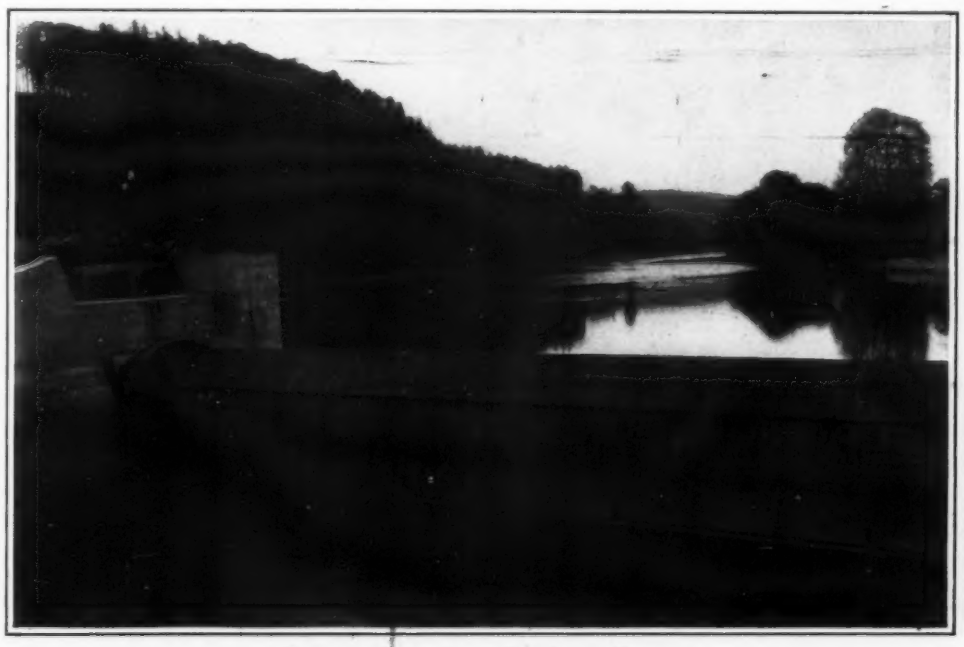


Fig. 4—Plan and sections of unattended lightship

French roller weir at St. Michel, Savoy, on the Arc



German roller weir at Trostberg, Alsace

Hull Form for High Speeds

THE author studies the variation, with velocity V, of resistance R offered to the movement of hulls through the water, and evolves a criterion which makes possible the determination of profiles (in planes parallel to the water line) yielding minimum resistance. By the aid of a coefficient characteristic of its lateral convexity, it is possible to determine immediately the suitability of any hull for high speeds. The formulæ given are based on experiments conducted in the open with a great variety of types of vessel. Two categories of vessel must be distinguished, namely, those which maintain a horizontal position at all speeds, and those which change their plane of flotation beyond a critical speed W, for reasons and under conditions set forth in the paper. Vessels fall in the first or second category according as the coefficient w of lateral convexity of the hull is greater or less than 0.18; where $w = (\sin I . \sin I_m)$, I_m being the mean of the max. angles of approach I, I′ etc. of the water lines of the stem parallel to the plane of floating, among which I is that of the water line of this plane. Mathematical justification is given for the main features of design of racing boats, *i. e.* short length and flat bottom below the poop. The formulæ evolved are applied to a 35-knot torpedo-boat destroyer. In order to determine whether any form of hull is capable of assuming an inclination favorable to high speed, by submersion at the stern and corresponding rise at the stem, it is only necessary to determine whether w is less than 0.18, with a lower limit 0.09.—E. FOURNIER, in *Comptes Rendus.*

New Methods of Etching Show Hitherto Undiscovered Characteristics of Rail Steel

THE following points from a report of an investigation carried out under the direction of the Rail Committee of the American Railway Engineering Association are of special interest:

The discovery of the value of deep etching with strong acid is bringing out hitherto unrecognized defects in the interior of the rail head. The Altoona Laboratory of the Pennsylvania Railroad has for some time suspected that chemical analyses of samples from different parts of the cross-section of the rail do not give sufficient information as to its quality. Further, the usual micrographic etching solutions employed have proved unsatisfactory and definite results have been secured only when the specimens were etched for two hours in a mixture consisting of nine parts hydrochloric acid, three parts sulphuric acid and one part water, kept at 200° F. This brought out a remarkable number of longitudinal, transverse and irregular marks or depressions, and these marks, representing streaks of more soluble materials, proved the existence of serious non-homogeneity, which hitherto could not be discovered otherwise.

In a rail that had never been in service the deep etching with strong mineral acid mixtures brought out indications of irregularity of structure, whereas picric acid etching has failed to develop anything unusual. In this connection an observation is reported by J. B. Young, chemist of the Philadelphia and Reading Railroad, whose tests indicate the likelihood that flaws and cracks may exist in new rails which have been subjected to no strains except those developed in the rolling.

The second point brought out by the research of the Rail Committee is that statistics prove that about all transverse fissures occur in rails rolled directly from the ingot, while rails from reheated blooms virtually never fail in this way. If true, this would prove that defects of the ingot rather than excessive stresses are responsible for transverse fissures. As an editorial in *Engineering News-Record* (March 27, 1919, p. 599) remarks, it may be deduced from these data that there seems to be more promise in metallurgical studies of rail steel and examination of furnace and mill conditions than in the study of track service. This is indeed not surprising; the trend of present engineering practice is all in the direction of preliminary test, rather than of test through failure in service.

The Strongest and Most Durable Fiber*

The Cultivation, Preparation, Spinning, Weaving and History of Flax

By W. Norman Boase, C.B.E., Chairman of the Scottish Flax Spinners' and Manufacturers' Association

[Concluded from Scientific American Supplement No. 2270, for July 5, 1919, Page 7]

SPINNING

It is not possible, without slides or drawings, and difficult even with them, to give to non-technical people an intelligible description of complicated mechanical operations, but a general description of spinning and weaving will probably be of interest.

From the earliest days flax fibers have been drawn out and twisted into yarn for the purpose of making twines, ropes and woven fabrics.

The earliest appliance used was the spindle, and this is found depicted in old Egyptian drawings and paintings, and several of the actual spindles used in the times of the Pharaohs are to be seen in museums. One which is in the British Museum was found in a tomb at Thebes, and has still some linen thread on it.

The primitive wooden spindle was from 9 to 15 inches long, rounded, and tapered at both ends. At one end there was a notch in which the flax was caught while undergoing the twisting process, and near the other end a bulb of wood or clay was secured, to give momentum and steadiness to the revolving spindle. This was called a wharve or whorl (c.f.whirl). The flax to be spun was wound round a piece of wood called a rock or distaff, which was generally held under the left arm, and the spindle itself, after having flax from the distaff attached to its notch, was laid on the right thigh and made to rotate by drawing the right hand quickly over it. As the spindle continued to revolve in the air, or like a top on the floor, the fiber was drawn out by the hands from the distaff and twisted into a thread so long as the spindle continued to revolve. When the spindle came to rest the twisted yarn was wound round it, and it was again rotated from the thigh and the fiber again drawn out, twisted and wound round the spindle until it was filled, and the quantity it held gives the name to a now definite measure of linen yarn, namely, the spindle of 14,400 yards.

The wonderful dexterity obtained by spinners using this simple and primitive apparatus was extraordinary, and they were able to produce yarns of a levelness and delicacy unobtainable even by elaborate modern machinery, linen yarns being produced by hand-spinning of over 800 lea, that is, weighing 1 oz. for over eight miles of yarn.

Changes in modern spinning have had for their objects the rotating of the spindle by mechanical means, the automatic drawing out of the fibers, and with the combination of these the working of a group of spindles together.

One of the first improvements was the cutting of a groove in the wharve, and passing a band round this, and also round a large wheel, which was rotated by hand. This was known as the "bobbing wheel," and was used in various forms even up to the beginning of the nineteenth century. When fine yarns were made they received two spinnings. The first consisted in drawing out and slightly twisting the fibers into what is still known as a rove, and by the second spinning the rove was fully attenuated and twisted.

In the sixteenth century the axis of the large wheel was cranked, and a treadle added, whereby the spinner was able to rotate the spindle with her foot, and have both hands free for the drawing out of the fiber. Later in the same century a wooden flyer with forked legs was fixed to the end of the spindle, and a bobbin or double-flanged spool was slipped on the spindle, and having one of its flanges grooved was sometimes driven separately. The fiber was drawn through an eye in the flyer, led along one of its legs and fastened to the bobbin. The flyer was driven at a higher speed than the bobbin, and twisted the fibers about a common axis once for each revolution, and the bobbin wound up the length thus spun. Sometimes the bobbin was only driven by friction, fitting closely on the spindle and being kept back by the strain of the thread only turned as fast as the spinner, judging the amount of twist required, allowed. This machine was called the Saxony wheel, and by it spinning became a continuous instead of an intermittent operation.

During the seventeenth century a second spindle and flyer were added, and the spinner was thereby enabled to spin two yarns at once, one with each hand.

The problem which remained was how mechanically the fiber could be drawn out and twisted uniformly, and the successful solution of this problem changed not only the character of the textile manufactures, but the social habits of the whole people.

In 1738 Lewis Paul, asisted by John Wyatt, invented and patented a process of drawing out fibers by passing between pairs of parallel rollers, each succeeding pair of which moved faster than the preceding pair. In order to draw out and twist the fibers at one operation, the attempt was made to turn the rollers simultaneously about their vertical and horizontal axes, and twenty years later Paul patented the use of one pair of rollers working in conjunction with a bobbin driven faster than the rollers, and which drew, twisted and wound the thread.

Neither of these was commercially successful. Many others labored on the problem, but it is generally conceded that Richard Arkwright, a barber of Preston, achieved what others had striven for, and was successful where others had failed. What he really did was to combine Paul's drawing rollers with the spindle flyer and bobbin of the Saxony wheel, group the spindles and rollers in sets of four, and drive by water-power. This machine was called the Water Twist Frame, and patents were taken out in 1769 and 1775.

A few years earlier James Hargreave invented the spinning jenny, by the aid of which many threads could be spun simultaneously by one person. The spindles were placed vertically and rotated from a drum, and the rovings were mounted on a movable carriage, which was slowly drawn out by one hand while the spindles were revolved by the other. The inward run of the carriage enabled the spun threads to be wound on the spindles.

During the years 1774 to 1779, Samuel Crompton combined in the mule the drawing rollers of Paul with the stretching of Hargreave. Since this time there has been a host of inventors and adapters, but all modern systems of spinning are based on the inventions of Paul, Arkwright, Hargreave and Crompton.

Many of the later experiments had been made with cotton, but in 1787 John Kendrew, optician, and Thomas Porthouse, clockmaker, both of Darlington, patented, as they described it, "a mill or machine, upon new principles for spinning yarn from hemp, tow, flax or wool." This machine, or grouping of machines, appears to have been an adaptation of Arkwright's patents, and the sliver from the last series of drawing rollers was deposited in thirty-six cans, and in an untwisted state was carried through retaining and drawing rollers to the flyer and spindle. Each spinning frame had thirty-six spindles, divided into six heads, each of which could be stopped. Later the sliver was twisted, and the modern flax spinning frame is, except for numerous small improvements, worked exactly on these principles.

Kendrew and Porthouse erected a mill on the River Skrene at Darlington in 1787, and this is believed to be the first mill erected for the spinning of flax by machinery, though in the same year a mill was erected at Bervie, in Scotland, and the machinery was obtained from Kendrew and Porthouse, who also supervised the erection.

Within a very few years flax-spinning mills were erected at Leeds, and this locality became the headquarters of flax-spinning in England. Many small mills were also soon started in Scotland, principally in Fifeshire and Forfarshire. Some of the country gentlemen took an interest in the new industry, and one certainly attended the mill daily, and also frequently the yarn market at Forfar, which was thought singular for a country gentleman of high standing, and more accustomed to fashionable life and country sports than to anything like flax spinning. It is quaintly reported in an old chronicle that he was welcomed by the manufacturers, among whom, being portly, he looked a nobleman; but he was no match for them at bargain making.

At Leeds and Dundee steam-power was early employed, but most of the small country mills were driven by water-power.

Up to 1810 a few small mills had their spinning frames of twenty or thirty spindles driven by blind men, who stood at the end of the frame with a crank in their hand connected with a moving board under their feet, one or both being worked at a time. As fourteen hours were worked at this time, every day except Sunday, it is not surprising to learn that the driver had to have a rest of a few minutes every hour.

It was not till the year 1828 that flax-spinning machinery was started in Ireland, that is, forty years later than both in England and Scotland; but Ireland soon made up for lost time, and by 1862 had nearly 600,00 flax spindles, which have now been increased to just short of 1,000,000, whereas in England and Scotland the flax spindles in 1862 were 620,000, and today under 200,000.

Leeds, at one time the headquarters of flax spinning in Great Britain, had, in 1864, 198,000 spindles running, rather more than at present in the whole of England and Scotland. Now she has none.

HECKLING AND CARDING.

The first operation when the scutched flax reaches the modern spinning mill is heckling, that is separating and subdividing the numerous small flax fibers and removing the coarse fiber by combing over a steel toothed heckle. Hand heckling was carried out by throwing the end of a strike or handful of flax over the steel comb or heckle, and pulling the strike through the teeth, repeating this process as long as is required, and then reversing and throwing the other end of the strike over the heckle. The same operation is then repeated over finer heckles, until the requisite fineness has been obtained. The heckled flax is called eight, ten, twelve, sixteen, etc., heckle, designating over which heckle it has been finished, the eight heckle having eight pins to the square inch, the twelve heckle twelve pins to the square inch, and so on, and the short fiber which is combed out is called tow.

Hand heckling is now almost a thing of the past, and machine heckling is generally practiced, the flax being held in grippers and the heckle pins fixed on a revolving sheet drawn through it. The modern heckling machine, with automatic attachment which screws and unscrews the grippers, and turns the flax in order that both ends may be heckled, is one of the most up-to-date and labor-saving devices of modern times.

The processes which follow heckling are spreading, drawing, and roving, and, as already explained, these processes draw out and straighten the fibers into continuous slivers, which are mixed and again drawn out, until a level rove has been obtained; the methods adopted at the present day are similar to those mentioned in tracing the mechanical growth of machinery for spinning, but the sliver is carried forward between the retaining and drawing rollers on a series of bars fitted with steel pins (called Gill pins from the name of the man who invented them). These bars are driven a little faster than the retaining roller, and considerably slower than the drawing roller, so that the fibers being pulled through the pins are increasingly divided and straightened out.

This process is repeated at least three times, on each occasion a number of slivers being placed together, so that irregularities are equalized and a level rove, and thereby a level yarn procured.

The present spinning frame is a simple machine, whereby the twisted sliver or rove is passed between retaining rollers on to drawing rollers, moving at a greater speed, and thence through the throttle of the spindle over the arm of the flier on to the spinning bobbin, which is filled evenly by being raised and lowered automatically on the spindle.

The twist put on the yarn is such that the fibers will rather break than slide over each other.

Spinning in England and Scotland is mostly dry spinning, whereas in Ireland wet spinning is generally practiced. The wet spining frame is fitted between the retaining and drawing rollers, with a trough holding warm water through which the rove passes. The action of the warm water on the fiber and gum enables finer counts to be spun.

Tow, whether scutched or heckled, is not spread but carded. That is, it is passed over large toothed cylinders with strippers and workers separating and unravelling the fibers, and delivering a continuous sliver similar to that coming from the line spreading. Thereafter the drawing and spinning processes are the same, except that shorter reaches are required, owing to the fiber being shorter.

BLEACHING

The yarn, when spun, is reeled or warped into chains ready for the loom, or for the bleachfield.

*From *Jour. Roy. Soc. Arts* (London).

It is not possible to touch on the fascinating history of bleaching from earths and alkaline plants to butter milk, sulphuric acid and chlorine, but there is little doubt that the over whitening and over calendering of the present day linens is the reason why they do not wear so well as those made in our grandmothers' days.

WEAVING.

Weaving is the interlacing at right angles of two or more flexible materials, of which the longitudinal are called warp, and the transverse weft. Ovid tells of a contest in skill between Minerva and Arachne, in which Minerva lost, and in revenge half killed the presumptuous maiden by striking her with a shuttle, and then repenting, allowing her to live, but changed her into a spider to spin and weave incessantly as a warning to earth-born females not to dare to show themselves more gifted than their celestial betters. As you doubtless know, spiders are called arachnidæ, and have eight legs, two more than the ordinary insect, doubtless given them because of the complicated work of spinning and weaving. It is a matter for regret that we poor mortal spinners and weavers are not also specially endowed.

Probably the Egyptians invented the art of weaving, and there is certainly no handicraft more ancient or more universal. The original looms were either horizontal or upright; in both the warp was stretched on a frame and the weft threads interwoven by hand. Later, alternate warp threads were shed, leaving a space between them through which the shuttle containing the weft was passed, the warp threads being then moved up and down, interlocking the weft which was driven home by the lay. The shuttle was thrown by hand, and great dexterity was soon acquired and considerable speed.

Job says, "My days are swifter than a weaver's shuttle," but, as during his sufferings his days cannot have passed very quickly, it is doubtful if this was a compliment to the weaver.

The old hand loom weaver had his work cut out for him; not only had he to throw the shuttle dexterously and catch it in the other hand, but he had, by means of treadles, to shed the warp, and with the hand not meantime occupied with the shuttle to drive the weft home with the lay.

The present plain weaving is not nearly so arduous a task for the worker, for the warp is shed automatically, and the weft is driven across by the picker, which was invented by John Kay and patented in 1733.

Woven fabrics are very varied in texture and have an enormous range of application, from plain cloth, repp cloth and the various twills, to the damasks and other intricate weaves made by the wonderful Jacquard loom, which, although invented over one hundred years ago, is, except for a few details modified to give greater certainty of action and greater speed, still the most important invention ever applied to weaving.

In the heavier end of the flax trade, the cloth from the loom, after being calendered or mangled—that is, passed through or over heavy rollers—is ready for the market, but in the lighter end many clothes are sent to the bleachfield to be grass bleached or otherwise finished.

The first power-driven looms appear to have been started at Limehouse about 1812, but these were very few even thirty years later. By 1862 there were 4,666 power-driven looms in Ireland, and 10,066 in England and Scotland. Today there are 37,000 in Ireland and 17,500 in England and Scotland. Ireland has five times as many flax spindles as England and Scotland, and twice as many looms, but uses roughly only the same weight of raw flax, because the goods manufactured there are so much lighter than those manufactured in the rest of the Kingdom.

GENERAL SUPPLIES, ETC.

The experience of the great war has shown the vital necessity of linen goods for the supply of the Army, Navy, and Air Service; two-thirds at least of the total quantity of flax worked in our country having been used to produce goods for these services during the war.

It is not generally realized of what great service flax has been to us in the war. Lord French, speaking in Belfast in the autumn of 1918, said: "The war in the air has been won on Belfast wings," and that is, without doubt, true; but there were also many other flax manufactures essential for the successful carrying on of the war. Linen duck for tents, covers of all kinds for transports, wagons, ammunition, stores, etc., Royal Navy and Merchant Navy canvas of various numbers and weights required by the Admiralty, hangar canvas for making shelters for our aeroplanes and airships, linen threads for sewing of all kinds and descriptions, and many other goods besides.

The linen trade was unable to supply the goods required, and many substitutes had to be resorted to, principally cotton and jute. It is not befitting for a linen spinner and manufacturer to decry other textiles, but it is an undoubted fact that the best advertisement linen ever had was when other textiles had to be used instead of it.

The increasing demands of the war supply departments necessitated, in 1917, the formation of a Flax Control Board with sub-committees in Belfast and Dundee, to ration the raw material and to license the manufacture of yarn and goods. This Board not only stimulated the normal sources of flax supply in Ireland, but arranged for Government joining with the trade in guaranteeing a large sum of money—£800,000—for cultivating an additional acreage in Ireland; and further, as the supply of fiber seed usually obtained from Russia and Holland was not only scarce but likely to be unobtainable, the Flax Control Board persuaded the Treasury to agree to sowing 30,000 acres in Canada for the production of seed only.

It is the habit to curse controls of all kinds, and no business man wishes to see them continued, but the linen trade of the United Kingdom has every reason to applaud the work done by the Flax Control Board and its committees.

The Empire Flax Growing Committee of the Board of Trade has been, for the last fifteen months, taking evidence regarding where flax can best be grown in our Empire, and its first report will shortly be issued. Enough to say that there are many places in our Empire where flax can be grown, notably British East Africa, where already a considerable quantity of land is under flax cultivation.

Now that war demands have ceased, the present position of the linen industry is lamentable. Nobody appears to require flax goods of any kind. Doubtless the very high price of the raw material, about five times the pre-war value, decreases the volume of business. Certainly the industrial unrest, the general want of confidence due to the reaction after war, and the non-settlement of peace terms, coupled with the continuance of the blockade, preventing the mending of the broken links in the chain of commerce; deter buyers from entering into fresh obligations; but with the certainty that the law of supply and demand will level prices of raw materials and goods, with the knowledge that linen is the greatest and best of all vegetable fibers, with the determination that our spindles and looms shall be worked economically to the best advantage, which must include the co-operation of labor, giving good work for good pay, we should not fear that the linen industry will not only maintain its prestige of the past but increase it in the future.

DISCUSSION.

The chairman (Sir Frank Warner, K.B.E.), in opening the discussion, said: What had struck him in regard to the operations in the early stages connected with the raw material was the primitive method of treating it. The author had explained in his paper that the best method of harvesting flax was to pull it, the reason being that that avoided the gathering in of weeds at the same time. Probably the method of pulling by hand would never be equalled, but at the same time if anything could be done to develop a pulling machine it might go far to overcome the labor difficulty which was met with at harvesting time—although he was not sure that any machine could be devised which would overcome the difficulty of pulling up weeds at the same time as it pulled up the flax. The same thought had struck him in regard to the retting process—that the ordinary retting which was carried on by farmers for so many generations was a very primitive one. The attempts which were now being made to establish retting tanks in localities where the farmers could bring their flax and dispose of it to a professional retter might go far to making the flax industry a more popular one with the farmers. There was no doubt that in connection with that there was room for scientific research. Research might not succeed in solving every trouble, but if it did no more than doing away with the nauseous odor of retting it would, from his point of view, achieve something. He did not know how far modern scientific research had dealt with the question, but the retting of flax was something on the same lines as the de-gumming of silk, and he thought it might easily be found that our raw materials might yield to a scientific treatment of the problem. At the present time, however, processes were liable to be of the "Do it quick and do it cheap" variety, without regard to the qualities of the fiber concerned. He thought that would be found true of the later stages of the linen—at all events it was true of the treatment that one's cuffs and collars received at the hands of the modern laundry. Another point which anyone who had had to deal with the subject would be struck with, was the great opening there was for mechanical improvement in all the earlier stages of pulling, de-seeding and scutching. Attempts had, of course, been made recently which did great credit to those who had taken part in them, but as yet the threshold only had been crossed into the great wide world of possible achievement. One great thing which the flax industry in this country had to face was the cheap labor in Russia, and that he was convinced could be met and overcome only by labor-saving appliances and machinery in this country. If the same amount of inventive skill was applied to arts of peace as had been applied to the arts of war he was confident that we should win in the flax industry as we had won in more difficult and apparently more hopeless circumstances. He would like to say one word on the importance of flax supply in time of war. As the author had pointed out, flax had proved of national importance, and if that had been the case in time of war it should not be forgotten in time of peace. Twelve months ago we had been fighting with our backs to the wall for our very existence. We had had a narrow escape. We were told that there would be no "next time" with regard to war. That was a very optimistic way of looking at it, but he did not think too much reliance should be placed upon it. Great Britain must not lose its rural arts; if it did it would become like the gentle reindeer—an easy prey to the wolves and wild dogs of the nations of the world.

Microstructure and Disintegration of Blast-Furnace Slags Rich in Lime

THE microstructure of a slag obtained in smelting for pig iron for use in the basic process is described in *Stahl und Eisen* and illustrated by means of 18 photomicrographs. Its composition is given as SiO_2 31.82, Al_2O_3 17.11, CaO 42.01, MgO 2.85, FeO 0.84, MnO 2.63, CaS 2.11, and P_2O_5 0.17%. The principal crystallographic constituent was melilite, which is regarded as an isomorphous mixture the two end-members of which are gehlenite ($3RO,Al_2O_3,2SiO_2$) and akermanite ($4RO, 3SiO_2$). Besides melilite the microsections show practically nothing but glass, the quantitative ratio between melilite and glass varying from about 1 : 10 to 1 : 2. When the melilite crystals are fully developed but little glass is present, and usually another silicate, regarded as lime-olivine, appears. The latter separates after melilite. Another slag of very similar composition showed a considerable quantity of lime-olivine in the melilite crystals. These inclusions were observed only in the case of slags showing a tendency to crumble, and unequal expansion of the two constituents is advanced as a possible explanation of disintegration. Slags containing more than 43 per cent. CaO must be regarded as likely to undergo distintegration.—*Jour. Soc. Chem. Ind.*

"Planeurs Captifs" for Meteorological Work

THE author holds strongly that there is a great future for scientific kite flying for meteorological work, aerial photography, signalling, etc. Numerous societies existed in France before the war for the encouragement of kite flying, but the work of these in educating the public to the importance of the subject was interrupted by the outbreak of hostilities. It is proposed that an association should be formed embracing all such societies, and that there should be close co-operation between the different workers. Government assistance is desired especially in the provision of suitable grounds for the experiments in different parts of the country. The work must be carried out in a scientific manner, and all results of importance published. It is recommended that the name "kite" (cerf-volant) be dropped as being suggestive of a toy, and "Planeur Captif" adopted instead. The features which the apparatus should embody are sketched out. Thus the kites should be easily collapsible for storage, and yet rigid when erected. They must be stable in flight, and must act as a parachute if a sudden drop of wind occurs. They should fly in winds of from 5 to 25 m.s. In the scheme outlined for man lifting a pilot kite is first sent up and the train of lifting kites attached to the cable at intervals of 10 to 30 m. A basket travelling up the cable is used for the observer. The winch is preferably mounted on a lorry with separate motors for winding in the cable and driving the lorry. A dozen men have been found to be sufficient to manipulate a train of man-lifting kites. Sketches show several suggested forms of kite both of the monoplane and box types. Details of construction are also shown.—*L'Aerophile.*

New Method In Photogrammetry*

An Accurate and Convenient Method for Photographic Surveying with any Camera

By Dr. Robert Heindl, Dresden

TRANSLATOR'S PREFACE.

UNDER photogrammetry we understand the fixation of the measurements of an object from its photographic picture. Though photogrammetry is as old as photography itself, its application in criminalistic cases began only with Bertillon, whose apparatus was first described by Professor R. A. Reiss, the well-known director of the Institute of Scientific Police of the University of Lausanne, in his article "Un nouvel appareil de photographie métrique appliqué aux constatations judiciaires" (a new apparatus for metric photography used in legal cases).[1] In the meantime, La Cour-Berthiot published in 1912 *La Photographie métrique de Bertillon*, edited under the supervision of Bertillon, a well-illustrated book outlining his system of metric photography.

BERTILLON'S METHOD.

Bertillon called attention to the fact that in some cases it would be most important for the examination of a crime to have a picture of the place of crime, from which all measurements of the photographed objects could be calculated; he constructed his well-known "special" camera by means of which it is possible to produce such metric photographs.

This apparatus, however, has two serious disadvantages: (1) It is very expensive, and (2) its use is made impossible when photographs have to be taken, for instance, of very small rooms, etc. Only objects can be photographed with this "special" camera, which are 150 cm. (approximately 5 feet), or more, distant from the lens. This camera can never be placed lower or higher than 150 cm. above the ground and cannot be pointed upward or downward. Experience has proven how frequently crimes are committed in narrow rooms and other places where it is impossible to make use of Bertillon's apparatus. For practical purposes we must have a photogrammetric method, where (1) any ordinary camera can be used without special cost or labor-expenditure, (2) which permits any desired position of the camera (made necessary by the room-conditions of the crime, and (3) which enables us to photograph objects which are nearer than 150 cm. from the lens.

Bertillon realized the shortcomings of his apparatus and experimented with an ordinary camera for making photogrammetric pictures for criminalistic purposes. R. A. Reiss describes these experiments in his book *Vols et Homicides* (*Theft and Homicide*) on page 368 and following:

"White paper strips, each of 1 m. length and 5 to 10 cm. width, are cut; every decimeter (3.937 inches) on these strips is marked by a black line. As many of these strips as possible are attached to the walls, etc., of the room.

"In order to calculate from the photograph the different distances, the length of the strips are measured on the picture and the obtained millimeter numbers are divided in the number 1,000. The difference of the quotients, multiplied by the focal length, express the natural and actual distances between the white paper strips.

"For instance, it has been found by measurement that of two strips the one measures 80 mm. on the photograph and the other 25 mm. The reductions are 1,000 ÷ 80 = 12.5 and 1,000 ÷ 25 = 40. The difference between 40 and 12.5 is 27.5. This number is multiplied by 10 (focal length in cm.) and we obtain therefore 275 cm. (approximately 9 feet) as the actual distance between the two strips. In order to calculate the distance of the 80 mm. strip from the camera, we have to multiply its reduction number 12.5 by the focal length 10; the result is therefore 125 cm. (approximately 3 feet 5 inches).

"If the reduction of a strip is known, the reduction of all objects that are situated in the same picture-plane are known. It is obvious that the calculation is only then correct when the apparatus stands 'rigorously' in a horizontal position."

Bertillon's method cannot be called a simple one; it is too circumstantial and much too cumbersome. The numerous white paper strips on the place-of-crime photographs are very annoying; its greatest fault, however, is that all objects not situated in the picture-plane of one of these strips, can be measured only approximately, but not exactly. Aside from being too laborious, the method is primitive and unsatisfactory in its results.—*R. de Réaillac Rosé.*

HEINDL'S METHOD.

Dr. Robert Heindl's new method for the metric photography of rooms, objects, etc., is the following:

A white board 50 cm. square is placed on the floor of the location to be photographed; this board is the measure, which is co-photographed and from which the dimensions and angles before us can be read off without difficulty. (Fig. 1).

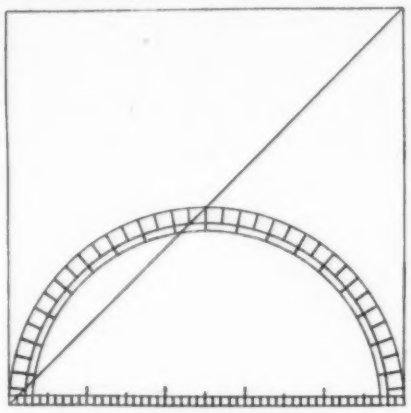


Fig. 1—Heindl's protractor

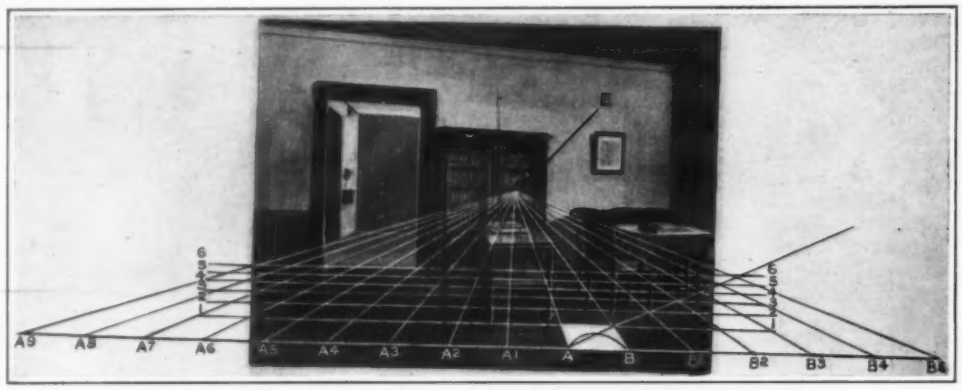


Fig. 2—View of a study surveyed and measured by Heindl's method

This board has at its lower edge a centimeter scale. The diagonal is drawn in the square and a half-circle with the degrees 1 to 180. The most satisfactory pattern employs solid sheet iron, painted white, because we thus obtain a perfect plane and a plate of not too great thickness. The lower edge of this board must appear perfectly horizontal on the diffused plate. This is the only rule to be considered in taking the picture. The camera may be placed at any height and tilted in any direction demanded by the problem.

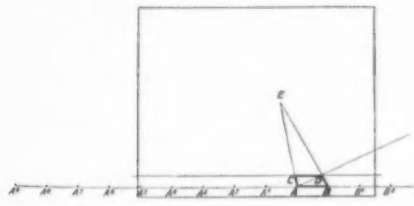


Fig. 3

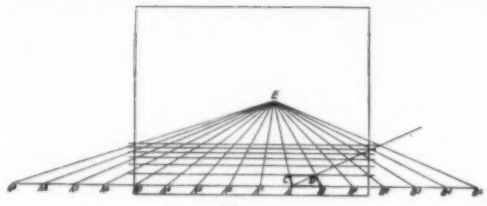


Fig. 4

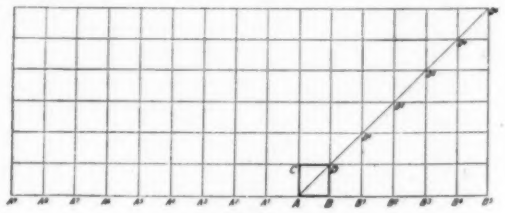


Fig. 5

Development of the survey of the study, Fig. 2 by Heindl's method

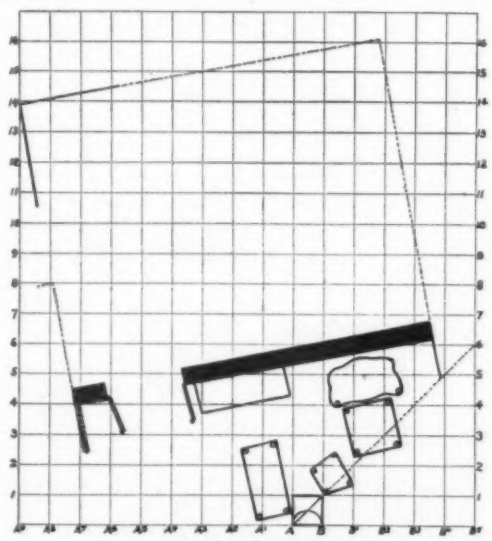


Fig. 6—Completed survey of Fig. 2

The picture of a study presented in figure 2 will serve as an example for the calculation of its measurements, and figures 3, 4, 5 and 6 will illustrate the drawing of a ground-plan according to this new method.

(1) DRAWING A GROUND-PLAN BY HEINDL'S METHOD.

On the photograph we prolong the four edges and the diagonal of the white board. The prolongation of its lower edge, which we call the "ground line," is divided into equal parts, so that $AB = BB^1 = B^1B^2$, $= AA^1$, etc. (Fig. 3).

From the intersection E, connecting lines are drawn to the intersecting points A^1 A^2, etc., B^1 B^2, etc. (Fig. 4).

Then we draw through the points, where these connecting lines bisect the prolonged diagonal (D^1 D^2, etc.), parallels to the line AB (Fig. 5).

This is the whole procedure by which the plane (the floor of the study) has been divided into squares of 50 cm. on a side thus enabling one to make a diagram of the ground-plan without any difficulty whatever, and on this ground-plan every object is readily plotted as shown by Fig. 6.

(2) DRAWING A GROUND-PLAN BY BERTILLON'S METHOD.

A frame has to be attached to the front of the plate in the camera; this frame carries 4 pins that indicate the horizontal and vertical line. These pins are co-photographed at the taking of the picture and appear on the positive as four black lines on the margin of the photograph. Before the exposure is made the plate must be placed in an exactly vertical position by means of a spirit-level; the tripod is then adjusted until a plumb-line shows that the objective-height is exactly 150 cm. The focal distance of the objective must be known; in the following example we suppose it to be 10 cm., and that the angular aperture objective equals 90°.

*Translated for the SCIENTIFIC AMERICAN SUPPLEMENT, from *Archiv. Kriminal-Anthropol. u. Kriminalistik*, 1916.

[1] Photographie Judiciare, Paris, 1903.

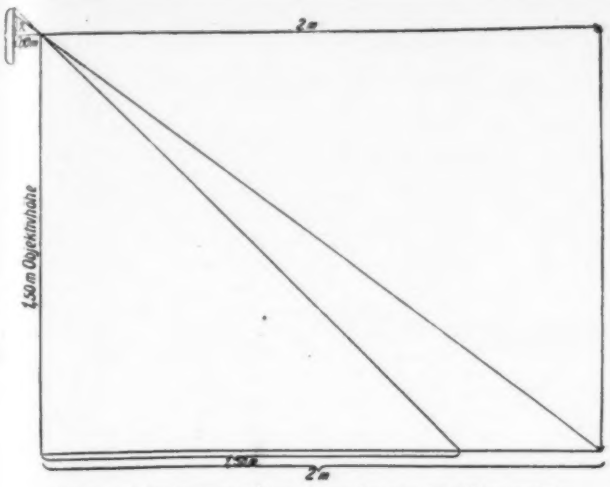


Fig. 8—Fundamental dimensions for the Bertillon system

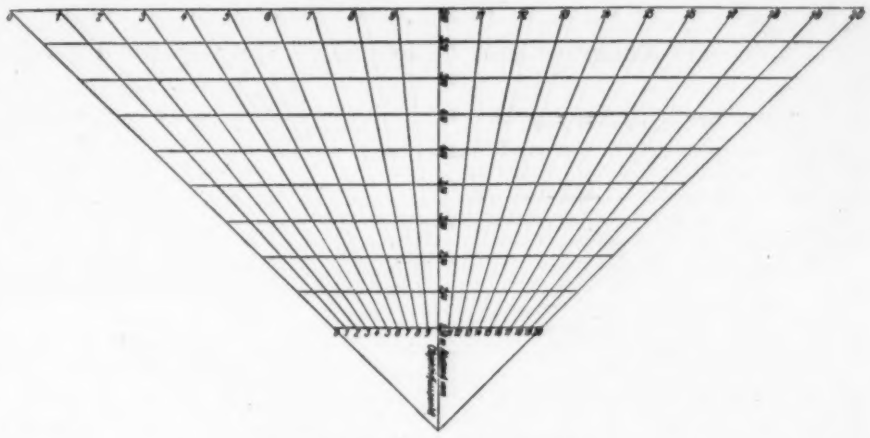


Fig. 9—Bertillon's "Perspectometer"

After observing all these precautions, the picture is taken. We then draw on the latter first the horizontal line joining the two indicator-pins appearing at the sides of the view. This line represents the horizon-line of the picture. The lower edge of the picture represents, therefore, on the produced plane a straight line whose distance from the foot-point of the lens equals 150 cm., the angle of the objective being 90 degrees (Fig. 7 omitted).

In order to draw on the photograph the straight line, whose distance from the lens footpoint equals 2 meters (a parallel to the lower picture edge at 50 cm. natural distance), the following calculations have to be made (Fig. 8):

x : 0.10 m. (focal length) = 1.50 m. (lens height) : 2 m. (distance of the straight line from the lens foot-point). $x = \frac{1}{2}(0.10 \times 1.50) = 0.075$ m. meaning that a parallel has to be drawn on the photograph distant 75 mm. from the horizon-line. This parallel represents, then, the desired straight line, which in nature is 2 m. distant from the lens point.

To obtain the straight line whose distance from the lens foot-point equals 2.50 m., the following calculation is necessary: $x = 0.15/2.5 = 0.06$ meaning the desired straight line has to be drawn on the photograph 60 mm. below the horizon-line, parallel to the latter.

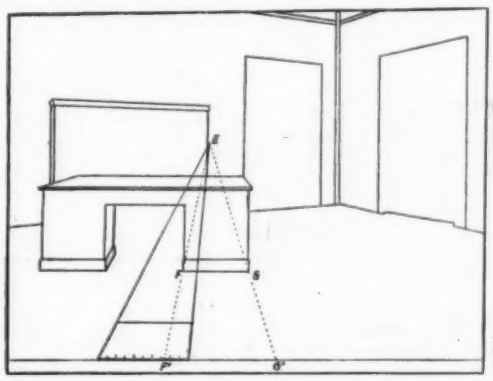


Fig. 10

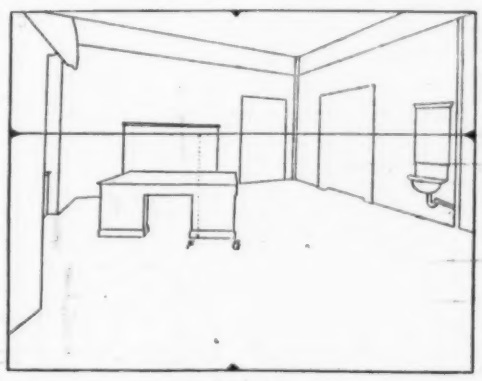


Fig. 11

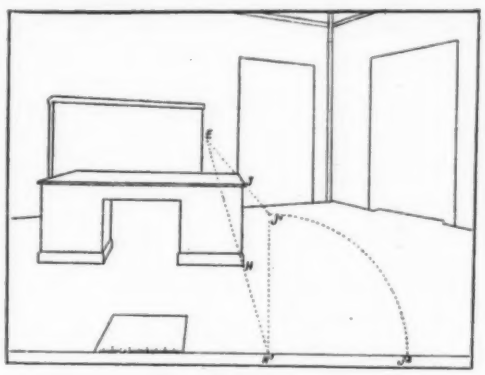


Fig. 12

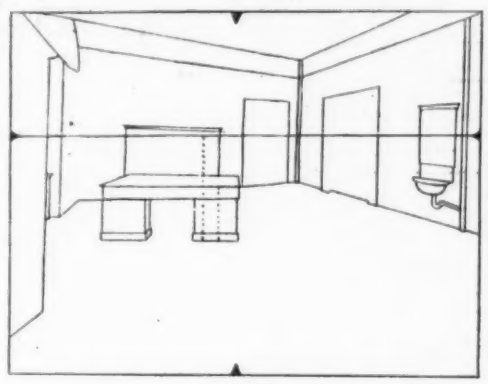


Fig. 13

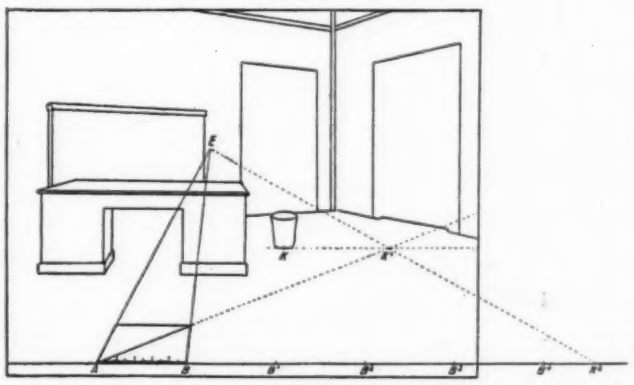


Fig. 14

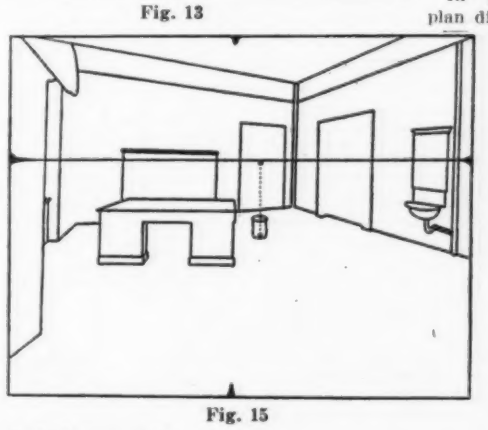


Fig. 15

Heindl's (left) and Bertillon's (right) methods compared

According to this calculation, we obtain for the straight line whose actual distance from the objective foot-point is 3 m., on the photograph a line 50 mm. below the horizon-line, and for similar lines to a distance of approximately 6 to 10 m., corresponding lines on the photograph. When all these calculations are complete, we draw on the photograph through the two indicator-pins, that are visible at the upper and lower edge of the photograph, a connecting line, representing the main-vertical line.

Then we draw on the photograph to the right and left of the main-vertical parallel lines at intervals of 1 cm., i. e. 20 lines, as the usual size of Bertillon's measure-pictures have 20 cm. width. The net, which has to be drawn on the photograph, is herewith completed. Now the diagram for the ground-plan must be drawn. While for Heindl's method any checkered paper, as used for plan-drawings, can be employed, Bertillon designed a "perspectometer" (Fig. 9).

This "perspectometer" is constructed as follows: An angle corresponding to the picture-angle of the objective, e. g. a wide-angle-objective of 90°. Then we divide this angle into halves; herewith the "main-vertical" is obtained, which runs perpendicularly through the center of the picture. On this "main-vertical" we lay off, in the desired ratio (e. g. 1:100), the distance 150 cm., i. e. the distance of the lower edge of the picture from the objective foot-point. At the terminating point of this distance we draw, perpendicular to the main-vertical, a line to the sides of the right angle, and divide this line into 20 equal parts, corresponding to the number of verticals which we have drawn on the photograph. Then we draw through the 20 division-points straight lines that bisect in the lens-footpoint. Finally we mark on the halving-line of the fan (the main-vertical), in the corresponding ratio, distances of 50 cm. and through the intersections thus obtained draw perpendicular lines to the main-vertical. The resulting lines correspond to the horizontal lines drawn on the photograph. Now we can begin the diagram of the ground-plan by entering the points of the photograph in the "perspectometer."

At first glance it becomes obvious that such a construction according to the Bertillon method is far more laborious and cumbersome than by the Heindl method.

(1) CALCULATION OF THE LENGTH OF A STRAIGHT LINE WHICH APPEARS ON THE PHOTOGRAPH PARALLEL TO THE GROUND LINE

In practice a ground-plan diagram will suffice to illustrate in court or at the first examination of the case, the distances of the different objects from each other and their respective dimensions. When more exact measurements are required, their calculation from a photograph is as follows:

Figure 10 represents a study, photographed according to Heindl's method, in the reproductions only indicated by diagram.

Figure 11 represents the same study, photographed according to the Bertillon method, in the reproductions only indicated by diagram.

Heindl's Method.—We draw on Fig. 10 from point E lines through the two ends of the straight line in question, FG, to the ground-line. The distance from F^1 *to* G^1, which we can read off from the ground-line by means of the centimenter scale on the board, corresponds to the actual length of the line FG.

The actual width of the right drawer of the writing-desk, for instance, is 62 cm.; 13.5 cm. are on the white board and 48.5 cm. lie outside of the board.

Bertillon's Method.—We have to measure first the

distance of the line *FG* from the horizon on the photograph; suppose this distance is 4.6 cm. Then we divide the lens-height (150 cm.) by this number:

$$150 \div 4.6 = 32.6$$

and obtain thereby the "reduction" of the line *FG*. Then we find the length of the line *FG* on the photograph (1.9 cm.) and multiply this number by the "reduction" number 32.6, and obtain the actual length of the line *FG*, i. e. 61.9 cm.

The comparison of both methods reveals a slight difference of 1 millimeter; both methods are accurate and reliable, but a division and multiplication is necessary in the Bertillon method, which easily may result in errors while in the Heindl method the number in question can be read off without any difficulty as from a calculation machine.

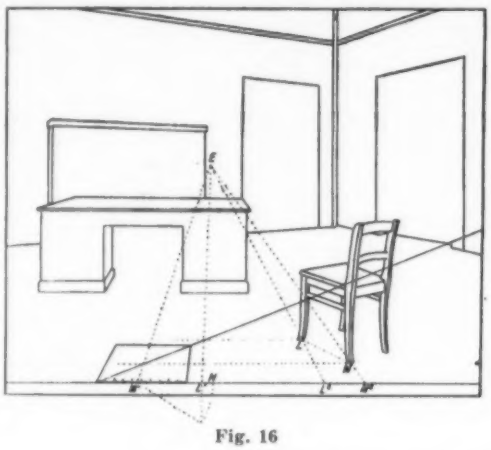


Fig. 16

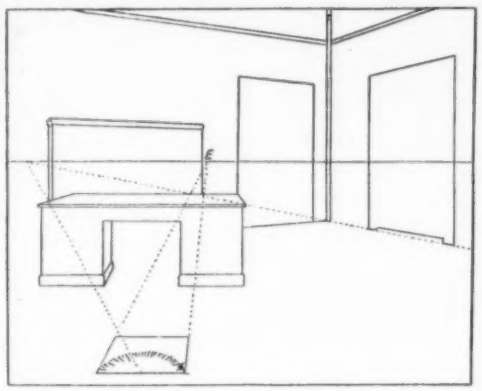


Fig. 17

(II). CALCULATION OF THE HEIGHT OF OBJECTS.

Heindl Method.—Figure 12 represents a desk, whose height, *HJ*, we wish to find.

Lines are drawn from *E* through *H* and *J*, a perpendicular is erected on the ground-line at H^1 the line H^1J^1 is transferred to the ground-line, and the distance between H^1 and J^1 is read from the centimeter scale on the board; $H^1J^1 = 79$ cm.

Bertillon Method.—We measure on figure 13 (the photograph of the object in question) the distance of the object's foot-point from the horizon-line, which we have supposed is 4.6 cm. Then we divide the lens-height by this number and obtain hereby the "reduction," i. e.

$$150 \div 4.6 = 32.6.$$

The height of the object is measured on the photograph (2.4 cm.) and this centimeter number is multiplied by the reduction number, and the result is the actual height of the object: 2.4 cm. $\times$ 32.6 = 79 cm.

(III). CALCULATION OF THE DISTANCE OF OBJECTS FROM THE GROUND-LINE.

Heindl Method.—For example, the distance of the waste-basket from the ground-line is to be calculated (Fig. 14).

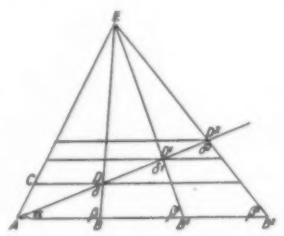


Fig. 19

Through *K* a parallel is drawn to the ground-line; then through the intersection of this parallel with the diagonal (K^1) draw from the main-point (*E*) a line to the ground-line *E* K^2. We read off *A* K^2, which equals the distance of the waste-basket from the ground-line. In this case, for instance, 2.80 m.

Bertillon Method.—We measure on the photograph the distance of the waste-basket from the horizon-line and obtain, for instance, 3.45 cm. Then we divide the product of the picture-distance (10 cm.) and the lens-height (150 cm.) by this number,

$$1500 \div 3.45 = 435,$$

and subtract 150 from 435, obtaining the distance of the paper basket from the ground-line, i. e. the line, which is represented at the lower end of the picture; in our case = 435 — 150 = 2.85 m.

On comparing both methods we find a difference of 5 cm. The actual distance, which was measured directly in anture, was 2.82 m. Such inaccuracies are unavoidable in either method when it is necessary to compute dimensions which are located at a certain distance from the ground-line.

CALCULATION OF A LINE-LENGTH, WHICH IS NOT PARALLEL TO THE GROUND-LINE.

Heindl Method.—For instance, the distance between the chair legs *L* and *M* is to be found (Fig. 16).

We first find the distance of the points *L* and *M* from the ground-line, as described in (III), obtaining L^2 and M^2. Then we draw from *E* a line through *L* and *M*, and obtain L^2 and M^2. The perpendicular L^2 M^2 is erected at *L*. M^1N, being the line to be calculated, can be read off from the centimeter scale on the board, and we obtain as length of the line $LM = 42$ cm.

Bertillon Method.—It is impossible to use Bertillon's method in this case, his "distance scale" and "reduction scale" cannot solve this computation. Tomellini, the champion of Bertillon's system, remarks that oblique distances cannot be read off from the distance scale,

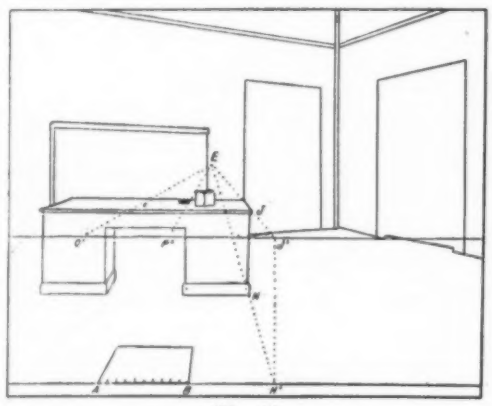
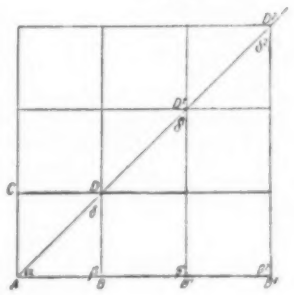


Fig. 18



but can be "approximately" calculated from the photograph. We know that such a line, in pictures taken by the Bertillon method, can be calculated by means of geometry and algebra (Pythagorean, logarithms, etc.), but what a loss of time!

CALCULATION OF ANGLES OF THE GROUND-PLANE.

For instance, we wish to find the angle of the right wall to the ground-line on Figure 17.

We prolong the line whose angle with the ground-line is to be calculated, until it bisects the horizon. Then we draw a line from the intersection point to the center-point of the protractor of the centimeter scale. The angle can then be read off; in this case = 67 degrees.

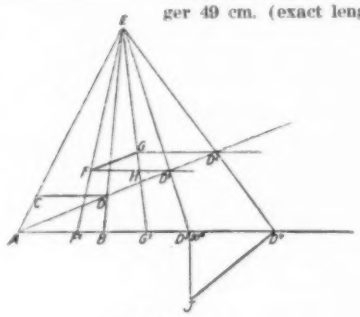


Fig. 20

By this method it is very easy to calculate also the distance of a point from the ground-line. If we do not care to use the previously described method (III), it is only necessary to connect the point in question with the center of the "protractor" and with the point *E*. The connecting-line with *E* must be prolonged to the ground-line, by which we obtain a triangle of which we know one side (part of the ground-line) and two angles one of 90° and the other to be read off from the protractor board. The length of the second cathetus can be calculated without difficulty and represents the desired distance.

Bertillon's method cannot be used in such cases.

CALCULATIONS OF LINES IN A PLANE SITUATED HORIZONTALLY TO THE GROUND-PLANE.

For instance, calculation of objects on the table in Fig. 18.

First, we find the height *HJ* of the plane by drawing from *E* lines through *H* and *J*; we obtain then H^1J^1. Then we draw through J^1 a parallel to the ground-line A B. This parallel represents the ground-line for the calculation of all dimensions on the table-plane.

Suppose we wish to calculate the length of the dagger *OP* on the table; all we have to do is to draw from *E* lines through *O* and *P* until they bisect the parallel and then with dividers measure the distance O^1P^1 on the ground-line *AB*. We obtain as length of the dagger 49 cm. (exact length 48.2 cm.) The height of the pasteboard box on the table may be calculated in a similar manner.

By this method we are able to calculate especially the dimensions of objects whose foot-points are only partly visible on the photograph; for instance, the depth of the writing table, whose nearest foot-points are only partly visible on the photograph.

Bertillon's method cannot be used in such cases.

VERIFICATION OF (I)—DIAGRAM OF A GROUND-PLAN, FIG 3.

The line *AB* and its prolongation the "ground-line," is not shown in perspective. As *AB* in nature measures 50 cm., the distances BB^1, B^1B^2, etc., correspond to this actual distance of 50 cm. The line *AB* is divided into centimeters, and herewith we have the centimeter-divisions of the distances BB^1, B^1B^2, etc., and have obtained a correct measure (i. e. the length of one centimeter) for the whole picture, to which we have to apply mathematically the dimensions of the photographed objects, in order to calculate them.

In order to obtain this mathematical relation, we have to determine first the so-called "perspective main-point" of the picture, which is obtained in the following manner:

We know that parallels converge at infinity. Their intersection-point, therefore, lies on the picture in the horizon. As the white board is a square one, the lines *AC* and *BD* are parallel, and the intersection point of their prolongations *E*, must for this reason lie in the horizon. The line which we draw through this point *E* parallel to the ground-line, is the horizon-line of the picture, and we have the point *E* as "perspective main-point," because *AC* and *BD* stand perpendicular to *AB*. When we draw from the points B^1 B^2 B^3, etc., connecting lines to the main-point *E*, we obtain therefore always parallels to *AE* and *BE* at intervals of 50 cm. each (see Fig. 4).

The floor of our study picture in Fig. 2 is, therefore, divided by these connecting lines into strips 50 cm. wide.

When the diagonal of the white board is prolonged, the constructions shown in Fig. 19 are obtained.

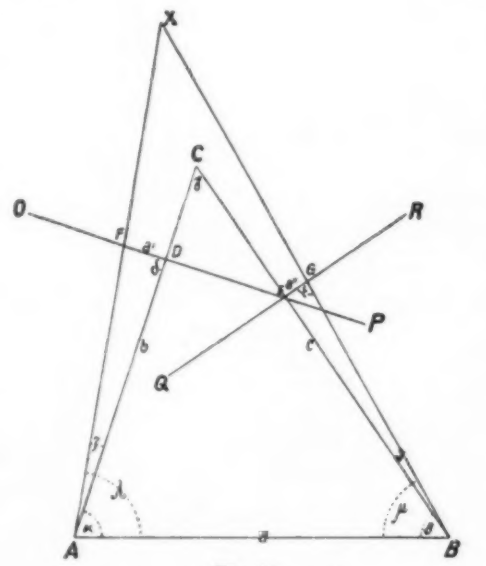


Fig. 21

The triangle $AB\ D$ is half a square, therefore an isosceles triangle. Angle $a = 45$ degrees, $\delta = 45$ degrees, and $\beta = 90$ degrees.

B^1D^1 is parallel to BD, therefore $\beta' = \beta = 90$ degrees, and $\delta^1 = \delta = 45$ degrees. The triangle $A\ B^1\ D^1$ is therefore also an isosceles triangle, and $B^1\ D^1 = AB = 1$ meter. The line drawn through D^1 is therefore 100 cm. distant from the ground-line.

We also can further prove that the parallel drawn through D^2 is 150 cm. distant from the ground-line, that the parallel through D^3 is 200 cm. distant from the ground-line, etc.

When we draw on the photograph parallels to the ground-line through all the intersection-points of the diagonal, we obtain squares 50 cm. on a side.

VERIFICATION OF
(IV)—CALCULATION OF A LINE-LENGTH NOT PARALLEL TO THE GROUND-LINE.

In Fig. 20, the line FG is the hypotenuse of a right-angled triangle with the catheti FH and GH. FH is known and equals F^1G^1. We also know GH, which equals the distance of the point G from the ground-line minus the distance of the point F from the ground-line, i. e. $= D^3D^4$. All we have to do is to join the catheti D^3D^4 and D^3J (the latter $= F^1G^1$ by the hypotenuse, whose length we read off from the scale of the ground-line.

PHOTOGRAMMETRY IN THE OPEN.

It is obvious that Bertillon's and Heindl's methods refer only to photographs of "even" locations, i. e. interiors. When metric photographs have to be taken in the open or in "uneven" locations, it is best to take two photographs. Heindl illustrates this with the following practical and actual case:

"A prick factory was torn down in Dresden in 1912; a very high chimney was dynamited, parts of which flew beyond the danger line and killed and maimed a number of people and wrecked some adjoining buildings. My duty was to determine what distance the killed and wounded persons and the wrecked buildings were from the chimney. To find these distances by actual measurements would have taken a great deal of time, and for this reason I applied photogrammetry.

"I took two photographs of the location from two different positions, with an ordinary camera. I had the distance between these two positions measured and also the angle of the optical axis and the connecting line of the two position-points. This was sufficient to calculate from the photographs all distances asked by the Court.

"The diagram shown in Fig. 21 will explain my calculations.

"At both the points A and B I took a photographic picture in such a manner that the point C came exactly in the middle-vertical line of the plate in both photographs. Then with a tape measure I measured the distance AB (= line a) and with a theodolite the two angles α and β (CAB and CBA).

"Then at the points D and E, 10 cm. distant from A and B, I erected OP and QR, perpendiculars to AC and BC, respectively. (The focal length of the objective was 10 cm.)

"In order to be able to enter on the diagram certain places of the photographed location, for instance, the place X, I measured on the two photographs the distance of the point from the lines AC and BC with dividers, transferred the found measurements a' and a'' on the perpendiculars OP and QR, drew a line from the two thus obtained points F and G to the two apices A and B, and found in this manner point X as the intersection-point of these two lines.

"When, for instance, the scale of the diagram is 1: 1000, i. e., when the straight line in nature measures 13 meters, we find by direct reading of the measurements from the diagram the distance $AX = 178$ m., and the distance $BX = 203$ m.

"The measurements of AX and BX are calculated as follows: We know in triangle ABC the line AB $(= a)$ and the angles α and β. We apply the sinus calculation: b, c and γ. In triangle ADF, we know the line AD (= 10 cm.), the line DF $(= a')$ and the angle δ (= 90 degrees); here we apply the sinus formula ξ. In triangle BEG, we know the line BE (= 10 cm.), the line EG $(= a'')$, b and ε (= 90 degrees); here we apply the sin formula ϑ. In triangle ABX, we know the line AB $(= a)$, $\lambda = a$ minus ξ and $\mu = \beta$ plus ϑ. Therefore with the sin formula: AX and BX."

A New Apparatus for Studying the Formation and Persistence of Fogs*

At a recent meeeting of the French Academy of Sciences M.M. A. Trillat and Fouassier made an interesting report upon their investigations of the causes which conduce to the formation of fogs and which govern their duration, as follows:

The condensation of atmospheric moisture in the form of fog depends not only on the amount of water vapor present and on sudden variations of the temperature, but is subject to the influence of other factors also, among which the presence of solid, liquid, or ionized particles seems to play a part of capital importance. Among the principal students of the influence of these factors we may mention Coulier, Mascart, Aitken, C. T. R. Wilson, and Langevin.[1] It may be recalled that as early as 1875 Coulier devised a very simple apparatus to demonstrate the action of smoke upon the condensation of water vapor in the form of a cloud and also that the ingenious "dust counters" of Aitken yielded interesting data concerning the number of "condensation nuclei" which exist in the air. The construction of the apparatus employed by us in our investigation of this subject, and which is suited to this double application, is based upon the following principles which we have verified experimentally.

1. The degree of aptitude for forming a fog possessed by a mass of calm air having a given temperature, pressure, and hygrometric index is mainly dependent upon the more or less persistent presence of solid or liquid particles suspended in the atmosphere;

2. The greater the number of active particles in the air under examination the less the degree of rarefaction necessary to cause the appearance of the fog in the case of any given kind of particles.

The apparatus consists of a balloon-shaped glass flask, having a capacity of ten liters and provided with two lateral tubular projections one meter in length and five centimeters in diameter arranged horizontally along a common axis. One of these is closed by an eye piece which permits the observation of a blackened disk forming the extremity of the second tube. The neck of the flask is closed by a stopper containing two orifices. Through one of these passes a tube provided with a stop-cock which permits the re-establishment of the atmospheric pressure in the flask or the introduction into it of the "condensation nuclei" to be studied. The second opening, which is provided with a T-tube, connects the interior of the flask with a double action rubber bulb and on the other with a manometer having a column of mercury provided with a scale.

In order to study the properties of the atmosphere of a given area we begin by expelling the air from the flask several times by means of the aspiration of the non-filtered surrounding air. The stop-cock is then closed and by means of the rubber bulb an increased pressure of several millimeters is produced, which is recorded. The atmospheric pressure is then suddenly re-established and observation is made as to whether this expansion produces the appearance of a fog, which is easily ascertained by the partial or total disappearance of the black disk. The operation is then recommenced, care being taken to renew the air of the flask each time until this result is attained; the degree of aptitude for forming the fog possessed by the air is readily measured by the manometer. When the degree of expansion is one millimeter or less of barometric pressure it may be concluded that the air of the flask, and consequently the external air is very favorable to the condensation of the moisture it contains in the form of a fog. This is the case, for example, in saturated air which contains very active particles. By an analogous operation the persistence of the fog may be estimated.

The apparatus enables us furthermore to make a separate study of the influences exerted upon the condensation of the moisture of the air by the nature of the particles of dust held in suspension. It is a well-known fact that the atmosphere contains innumerable corpuscles of very variable size and which may be of the magnitude of one one-hundredth micron and consequently invisible except when accidentally present in large numbers. Their origin may be mineral (Tissandier) or organic (Pasteur). Examination of them shows that their behavior differs greatly according to their origin: some of them play the part of very active nuclei of condensation, which induce condensation in air which is very far from being saturated; others act only when saturation is very near; and still others exhibit no activity.

Our investigations of this subject are not yet finished but the observations thus far made both confirm and complete those made by the authorities cited above.

The smoke particles proceeding from the combustion of charcoal and of both plant and animal products, particularly the latter, are endowed with a high degree of activity in condensation. However, our experiments indicate that a portion of this activity must be attributed to the gaseous products which accompany the said smoke and which are more or less ionized. Ammoniacal salts, magnesium chloride, and the emanations of mineral acids possess this property of condensing the moisture of the air into fog in a very high degree. The solid powder or dust which is derived from calcareous substances, from silicates and from iron oxide, and which constitute the major portion of the sediment of the atmosphere are less active than the ones mentioned above and form less persistent fogs. As for micro-organisms, we have already shown in a previous article that they are capable of condensing moisture in the form of microbian clouds.[2]

Among the more or less active particles of dust examined by us some are soluble in the vapor that contains them, while others are insoluble. In our tests we found that the first kind occasioned more persistent fogs than the latter. Possibly we may find an explanation here of the difference sometimes observed between the persistence of city fogs and country fogs.

In spite of present imperfections we indulge the hope that this apparatus, which is based upon the same principle as that of Coulier but is desgned to serve a different purpose, may prove of use in meteorological stations, aviation fields, etc., by furnishing information as to the greater or less degree of aptitude possessed by any given specimen of atmosphere for forming fogs and also for measuring the degree of persistence of the same.

[The authors appear to have overlooked the extensive and important researches on cloudy condensation, by Carl Barus who has demonstrated experimentally the formation of cloud or haze in absolutely clean air after ionizing and rarifying it. Barus concluded that ions are a prime source of nuclei of condensation.—Editor.]

Protection of Iron Against Rusting

Prof. Barff publishes a method of protecting iron from rusting that is more durable than any yet known. This method is of the greatest value for bridgework and other iron constructions. The iron to be treated is exposed at red heat to the action of superheated steam. This gives a surface coating of black iron oxide that is a complete protection against rusting. The protection thus afforded depends on the temperature of the steam and the length of the treatment. The coating is very hard, adheres very firmly, and shades off inappreciably into the unchanged mass of the iron.

If the iron is exposed in a chamber heated to 260° C. for 5 hours and acted on by superheated steam, a coating is formed that will withstand the action of emery-paper for a considerable time. If the temperature is raised to 650° C. and the time of treatment to 6 or 7 hours, the surface coating will resist the action of a file.

A great advantage of the system is that, if a part is left untreated and begins to rust, the rusting does not spread sideways to the treated portions.

Parts left for 6 weeks in the open air in rainy weather showed no traces of rust.—*Zeitschrift für Strassenbahnen; Schweizerische Elektrotechnische Zeitschrift.*

Turbines and Central Station Operation

It was the central station that created the demand for large steam turbines which have now grown to 70,000 kw. units. At the other extreme, turbines of 7½ kw. output are available for main-unit drive in small installations, and for driving auxiliaries such as pumps, fans, stokers and line shafts. A number of isolated industrial plants have recently installed turbines of 15,000 and 20,000 kw., and it is thought that this practice will extend, although the higher load factor of central stations, compared with most industrial plants, contributes to higher economy in the former. It is pointed out that modern central station service implies interconnected generating stations, judiciously located at load centres. Large isolated plants could generally be "tied in" with central stations to the great advantage of both parties.

Steel mills are usually placed favorably for cheap power generation by private plant. There is no reason why such plant should be eliminated. On the contrary, it is located at an important load centre, and all that need be done to secure maximum economy and highest load and diversity factor is to interconnect the isolated plant with the central station system. Increased security of service and better utilisation of plant would be secured. At the worst, interconnection is preferable to leaving matters as they are, and it is quite a feasible policy, whereas scrapping isolated plant is not always practicable even when justifiable.—*Electrical Review.*

*Translated for Scientific American Supplement.

[1] Carl Barus and Jas. P. Espey should be included.—Editor.

[2] *Comptes rendus, Paris,* 1914, v. *158,* p. 1441.

Flotation for the Practical Mill Man

(*Continued from page 35*)

(1) the natural amenability of the ore to the process, (2) the simplicity of the sulphide content of the ore being treated, (3) the sort of results that the flotation equipment is being operated to obtain, and (4) the skill and care with which cleaning the concentrates is done.

The first two of these factors are, to a great extent, beyond the control of the operators. However, the second two are of such a nature that they can be much influenced and controlled by the operators.

NATURAL AMENABILITY OF ORE TO FLOTATION.

It as been often found that two ores, apparently of the same physical and chemical makeup, respond very differently to flotation, the one giving maximum results without trouble, while the other can only be treated satisfactorily with the greatest difficulty. Just why this is true is often very difficult to explain.

It is, however, usually easy to obtain both high grade concentrates and high extractions when treating the ores that respond easily to flotation, the probable reason being that when dealing with this type of ores, a small amount of the lighter oils will give high recoveries of the sulphides present, and, at the same time, this type of oiling will in nearly all cases produce the richest concentrates.

When dealing with the other ores—those which can only be made to respond to flotation treatment with difficulty—it is usually necessary, in order to obtain high recoveries of the sulphides, to use a comparatively large amount of heavy flotation oils. This class of oils will, it is true, make high recoveries, but in so doing often float such large amounts of gangue as always to cause the concentrate to be low grade.

As suggested, these factors usually depend more on the ore itself than on any of the conditions that can be controlled. However, from the above it can be seen that when the ore is readily amenable to flotation, both high recoveries and rich concentrates can be produced by the same operation, but when the ore does not respond readily, high recoveries can be obtained with greater ease than high grade concentrates, and neither can be gotten at the same time.

In an ore composed of simple gangue minerals and only one flotable mineral, it is easy to see that the chance of producing high grade concentrate is greater than when two or more minerals that float are present.

COMPLEXITY OF SULPHIDES AND GRADE.

When several sulphides, such as lead, zinc and iron sulphide, for instance, are present in the ore, there are two possible schemes that might be used in overcoming the tendency for the production of, say, a low grade zinc concentrate. The success of either of these will depend largely on the character of the ore and its sulphide constituents. One of these methods involves the removal of one or more of the sulphides by gravity before the flotation of the ore for the recovery of the other sulphide. The other scheme depends on a differential or selective flotation operation to recover one of the sulphides without removing the other two. This has been done to a limited extent in various sections of the country, but at best it is a very delicate operation and will require large amounts of experimental work, careful control of the flotation operations themselves, knowledge of the relations of the various minerals to one another and, above all, great skill in the actual operation of the equipment.

There is no question that the grade of the flotation concentrates can be influenced greatly by some such schemes as those mentioned, but their success is bound to be limited. They are really special cases of flotation and should not be discussed here.

FLOTATION OPERATION AND GRADE OF CONCENTRATES.

Probably the greatest factor affecting the grade of the product is the manner in which the machines themselves are run from shift to shift. The grade of the concentrates will depend largely on (1) whether the machines are being operated to obtain the maximum recovery or the maximum grade of product, (2) on the skill and intelligence with which the oils are used, (3) on the skill and care with which the pulp level and depth of froth on the machines are controlled, and (4) on the pulp density.

The effect of the first point mentioned, the results that are being striven for on the machines, has been suggested already. Much of the concentration takes place in the froth column, and when the froth is allowed to discharge from the apparatus so slowly that most of the gangue has had time to drop from it, some of the mineral will also be dropped into the cells, causing a lowering in the recovery, but at the same time the maximum grade of product will result. Just the point at which these two conditions should be balanced is an economic matter and can only be worked out on the profit sheet of the mill.

The fact should be emphasized at this point that beyond a certain point the grade of concentrate can only be better at the expense of recovery, and vice versa. This will be the dominating thought that will be carried through any discussion involving extractions and grade of concentrates by flotation processes, or any other process, for that matter.

OIL AND GRADE OF CONCENTRATES.

The necessity for the intelligent use of flotation oils and reagents to obtain the highest grade of product from a flotation machine has also been suggested in another connection, and should be fairly evident. The strength and carrying power of the froth will depend largely on the kind and amount of oil used in the circuit. The grade of the concentrate also depends very largely on the same factors. If a weak froth can be made which will carry sufficient sulphide to give a high recovery, this froth, from its very nature, will not be prone to carry much of the gangue.

If a froth of a strong, stiff character is required to give high extractions, it will tend to carry much more gangue material and hence produce a lower grade of concentrate. As the oils are the dominating factor on which the strength and carrying power of the froth depend, the evident relation of the oils to the mineral purity of the concentrate should be clear.

Of course, the ideal practical condition will be to use the oil mixture that will prevent the flotation of the gangue to the greatest extent, and yet float all of the sulphides present in the machine. Under this condition the highest recovery will be possible, and the concentrate produced will be ideal for cleaning in the cleaner cells.

PULP LEVEL OR DEPTH OF FROTH.

The relation of the level of the pulp and the depth of froth to the grade of the concentrates was suggested in connection with the remarks on extraction. Slowly discharging froth and deep pulp level mean a long period of time for the contration in the froth column to take place, with the dropping out of a correspondingly large amount of impurities from the froth.

The operators can soon learn, under the different conditions that will be encountered, the correct depth of pulp to obtain the highest extraction and, at the same time, the maximum grade of concentrates. The pulp level will depend to a certain extent also on the quality of sulphides in the pulp fed to the machine.

As a general rule the larger the amount of sulphide that must be removed from the machine, the higher the pulp level will be carried, and the faster the froth will be discharged. The operators soon learn to judge these conditions, and make the necessary adjustments when they are required.

PULP DENSITY AND GRADE OF CONCENTRATES.

The reasons for the variations in the pulp density upon the grade of concentrates are a little more difficult to understand. The ratio of water to solid in a flotation machine has much to do with the character of the froth the machine is producing. Just why this should be true is hard to say.

It has been previously shown that the character of the froth affects the grade of concentrate. Now froth characteristics will continue to have the same effect on the purity of the concentrate, regardless of whether they can be traced to under- or over-oiling of the pulp, or by thickening or diluting it, as in the case now under discussion.

There is yet another manner in which the pulp density may affect the purity of the concentrate. It is the effect of the pulp density on the amount of sulphide that will be carried into the machine in a certain time.

A flotation machine can produce a given amount of froth of certain characteristics in a given period of time. If a dilute pulp is being fed to the machine, there will be fewer pounds of sulphide to be removed by this amount of froth; a condition that, due to its unsaturated condition, will increase the chances of the froth picking up the gangue material, and therefore lowering the purity of the concentrates.

As would be expected, increasing the pulp density will tend to have the opposite effect on the grade of concentrates. In this case, there is an increase in the amount of mineral to be floated by the available froth, causing it to become quickly saturated with sulphide and so leaving but little space for the gangue material. This result is probably brought about by the fact that the sulphides are the easiest to float and will have the greatest tendency to be attracted to the froth and hold there, in preference to the non-sulphide material. This condition in the machine will also tend to increase the concentrate grade, but at the same time lower the extraction.

(*To be continued.*)

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